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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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The Society as a body is not responsible for the statements of facts of opinions advanced in papers or discussions. C55

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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MEETING IN ENGLAND

The completed program of the Joint Meeting of The American Society of Mechanical Engineers with the Institution of Mechanical Engineers, now in progress in England, is as follows:

Monday, July 25

11.15 a.m. Members of the American Society and their ladies depart from Liverpool (Lime Street Station) by special train for Birmingham. Luncheon on the train.

1.15 p.m. Arrive Birmingham (New Street Station).

3.00–6.00 p.m. The Secretaries' Office will be open at the Birmingham and Midland Institute, Paradise Street, Birmingham, for the registration of addresses, issue of badges and tickets, etc.

Tuesday, July 26

9.00 a.m. The Right Hon. The Lord Mayor of Birmingham, Alderman W. H. Bowater, *Chairman*, Nevill Chamberlain, Esq., *Chairman of the Executive Committee*, and the members of the Birmingham Reception Committee, will welcome the President, John A. F. Aspinwall, Esq., the Council and the Members of the Institution, and the President, George Westinghouse, Esq., the Council, the Officers and the Members of the American Society, in the Lecture Hall of the Birmingham and Midland Institute. Reading and Discussion of Papers.

Presiding Officer, Am.Soc.M.E., W. F. Goss.

1.00 p. m. Luncheon in the Town Hall, by kind permission of the Right Hon. the Lord Mayor (ladies invited).

ALTERNATIVE EXCURSIONS

2.20 p.m. Visit to the Pump and Power Co.'s Testing Station at the Works of the South Staffordshire Mond Gas (Power Heating) Co. Ordinary trains to and from Dudley Port. Tea, by kind invitation of the Pump and Power Co.

Or,

2.00 p.m. Visit to the works of the Austin Motor Co., Northfield, by motor cars kindly provided by the company. Tea, by kind invitation of the Austin Motor Co,

Or,

2.30 p.m. Visit to the works of the Metropolitan Amalgamated Railway Carriage and Wagon Co., by special tramcars. Tea, by kind invitation of the company.

Or,

2.30 p.m. Visit to the Frankley Filter Beds of the Birmingham Corporation Water Works, by special motor omnibuses. (Ladies invited.) Tea.

Or,

2.10 p.m. Excursion to Stratford-on-Avon. (Ladies invited.) Special train to Stratford-on Avon. Visit places of interest. Tea. Special train to Birmingham, arriving 6.45 p.m.

Or,

1.30 p.m. Excursion to Worcester. (Ladies invited.) Special train to Worcester. Luncheon on the train. Visit the Cathedral, the Worcester Royal Porcelain Works, and the "Commandery." Special train to Birmingham arriving about 6.50 p.m. Tea on the train.

Or,

2.00 p.m. Excursion to Stoneleigh Park and Kenilworth by special motor omnibuses. (Ladies invited.) Visit Stoneleigh Abbey, by kind invitation of the Right Hon. Lord Leigh, Visit Guy's Cliff. Tea. Return to Birmingham.

9–11 p.m. Garden Fête in the Botanical Gardens, Edgbaston, by kind invitation of the Birmingham Reception Committee.

Wednesday, July 27

9.00 a.m. Secretaries' Office open,

10.00 a.m. Reading and Discussion of Papers. Presiding Officer, Am.Soc. M.E., E. D. Meier.

1.00 p.m. Luncheon in the Town Hall by kind permission of the Right Hon. The Lord Mayor. (Ladies invited.)

ALTERNATIVE VISITS

2.00 p.m. To the New Buildings of the University of Birmingham, opened in July 1909, by His late Majesty, King Edward VII. (Ladies invited. Special motor omnibuses to and from the University. Tea, by kind invitation of the Council of the University.

Or,

2.30 p.m. To Messrs. Mitchells and Butlers' Brewery, by special motor omnibuses. Tea by kind invitation of Messrs. Mitchells and Butlers.

9–11 p.m. Reception in the Council House by kind invitation of the Right. Hon. The Lord Mayor of Birmingham, Alderman W. H. Bowater and The Lord Mayoress.

Thursday, July 28

ALTERNATIVE EXCURSIONS

9.25 a.m. Coventry and Rugby. Special train to Coventry. Visit either the Daimler Works or Messrs. Alfred Herbert. Luncheon by kind invitation of either the Daimler Motor Co. or Messrs. Alfred Herbert. Special train to Rugby. Visit either Messrs. Willans and Robinson, or the British Thomson-Houston Co. Special train to London, arriving 6.35 p.m. Tea on the train.

Or,

9.35 a.m. Lichfield. (Ladies invited), Special train to Hammerwich. Drive to the South Staffordshire Waterworks Co.'s Pipe Hill Pumping Station. Visit the Pumping Station. Drive to Lichfield. Visit Lichfield Cathedral. Luncheon. Visit Dr. Johnson's birthplace and other places of interest in Lichfield. Special train to London. arriving 6.55 p.m. Tea on the train.

Or,

9.00 a.m. Kenilworth, Warwick and Stratford-on-Avon, by special motor omnibuses. (Ladies invited.) Visit Kenilworth Castle. Visit Guy's Cliff. Visit Warwick Castle, by kind invitation of the Right Hon. The Earl of Warwick. Luncheon. Visit places of interest in Stratford-on-Avon. Special train to London, arriving 7.37 p.m. Tea on train.

Or,

9.00 a.m. Stratford-on-Avon, Warwick and Kenilworth, by special motor omnibuses. (Ladies invited.) Visit places of interest in Stratford-on-Avon. Luncheon. Visit Warwick Castle, by kind invitation of Right Hon. The Earl of Warwick. Visit Kenilworth Castle. Special train to London, arriving 7.37 p.m. Tea on the train.

9. p.m. Conversazione in the Institution House, Storey's Gate, St. James's Park, London, by invitation of the President and Council of the Institution.

Friday, July 29

9.30 a.m. Secretary's Office open at the Institution, Storey's Gate, St. James's Park, London.

10.00 a.m. Reading and Discussion of Papers in the Lecture Theatre of the Institution of Civil Engineers, by kind permission of their Council, Presiding Officer, Am.Soc.M.E., Chas. Whiting Baker.

3.00–5.30 p.m. Garden Parties and Visits. Cards of invitation may be obtained at the Secretaries' Office in Birmingham and in London.

7.30 p.m, Institution Dinner in the Connaught Rooms, Freemason's Hall, Great Queens Street, W. C. (Evening Dress.) (Ladies invited.) Reception at 7.00 p.m. Address by Prof. F. R. Hutton, Hon. Secy.

Saturday, July 30

ALTERNATIVE EXCURSIONS

10.00 a.m. Windsor and Marlow. (Ladies invited.) Special train to Windsor. Luncheon in the Guildhall, Windsor. Special steam launches to Marlow. Tea. Special train to London, arriving 7.40 p.m.

9.45 a.m. Marlow and Windsor. (Ladies invited.) Special train to Marlow. Special steam launches to Windsor. Luncheon on the launches. Tea in the Guildhall, Windsor. Special train to London, arriving 7.20 p.m.

The guests at these excursions will be invited to attend the Japan-British Exhibition and the Garden Club during the evening.

6.30 p.m. The Council, Past-Presidents of the Society and their ladies will be entertained at dinner on Saturday evening by Sir William H. White, K.C.B., Past-President of the Institution and Honorary Member of the Society, and Lady White.

Sunday, July 30

Special services in Westminster Abbey, where seats will be reserved for the membership. Inspection of Sir Benjamin Baker Memorial window.

The following papers have been assigned to the several meetings:

Birmingham, Tuesday, July 26, and Wednesday, July 27

English Running-Shed Practice; by Mr. CECIL W. PAGET, Member, of Derby.

Round-House Practice, or the Handling of Locomotives at Terminals to secure continuous Operation; by Mr. FRANK HENRY CLARK, Member, *Am.Soc.M.E.*, of Chicago.

Handling of Locomotives at Terminals; by Mr. FREDERIC N. WHYTE, Vice-President, *Am.Soc.M.E.*, of New York.

Handling Locomotives; by Mr. HENRY H. VAUGHAN, Member *I.Mech.E.* and *Am.Soc.M.E.*, of Montreal.

American Locomotive Terminals; by Mr. WILLIAM FORSYTH, Member, *Am.Soc.M.E.*, of Chicago.

High-Speed Tools, and Machines to fit them; by Mr. H. I. BRACKENBURY, Member, of Newcastle-upon-Tyne.

Tooth Gearing; by Mr. J. D. STEVEN, Associate Member, of Birmingham.

Interchangeable Involute Gearing; by WILFRED LEWIS, Member, *Am.Soc.M.E.;* Discussion by C. R. GABRIEL, Member, *Am.Soc.M.E.*

Topical Discussion on High-Speed Tools, by Members of the *Am.Soc.M.E.*

London, Friday, July 29

Electrification of Suburban Railways; by Mr. F. W. CARTER, of Rugby.

Cost of Electrically-Propelled Suburban Trains; by Mr. H. M. HOBART, of London.

Economics of Railway Electrification; by Mr. WILLIAM B. POTTER, Member, *Am.Soc.M.E.*, of Schenectady, N. Y.

Electrification of Trunk Lines; by Mr. L. R. POMEROY, Member, *Am.Soc.M.E.*, of New York.

Electrification of Railways; by Mr. GEORGE WESTINGHOUSE, President, *Am.Soc.M.E.*, of Pittsburg, Pa.

The official party, comprising 160 members and guests of The American Society of Mechanical Engineers, sailed for Liverpool, Saturday, July 16, at 2 p.m., aboard the S. S. Celtic, White Star line. The Committee on Arrangements, Ambrose Swasey, *Chairman*, Charles Whiting Baker, *Vice-Chairman*, George W. Brill, W. F. M. Goss, John R. Freeman, and, ex-officio, George Westinghouse, President, F. R. Hutton, Honorary Secretary, William H. Wiley, Treasurer, and Calvin W. Rice, Secretary, and the sub-committee on Entertainment, Geo. M. Brill, *Chairman*, H. G. Reist, John W. Upp, George A. Orrok, Mrs. F. R. Hutton, Mrs. Geo. M. Brill, and Mrs. Jesse M. Smith, arranged for a most interesting program on board ship, which follows:

Sunday Religious Services

Monday Evening Reception by the officers and Past-Presidents of the Society

Tuesday Evening Illustrated Address. "What are the Astronomers Doing?" Worcester R. Warner, Past-President

Wednesday Evening Musicale

Thursday Evening Illustrated Address. "Construction of the Panama Canal," John R. Freeman, Past-President

Friday Evening Dancing

Saturday Evening Conversazione. Collection for Seamen's Benefit Fund. Awarding of Prizes

Sunday Religious Services

Bridge, deck games, etc., were arranged for several afternoons, and inspection trips were made daily under the direction of the officers of the ship. A dainty booklet, entitled Our Ocean Trip, containing the program, committees, etc., with blank pages for notes and autographs was furnished to each of the party, and served as a useful souvenir. The members presented to Captain A. E. Hambleton of the Celtic a beautifully wrought silver cabinet, and to the Chief Engineer, Mr. C. C. Lapsley, a reading lamp with Tiffany favrile glass shade, both suitably engraved.

The comfort of the party was further provided for by the subcommittees on Transportation, Charles Whiting Baker, Calvin W. Rice; on Publishing and Printing, F. H. Hutton, F. R. Low; on Finance, Wm. H. Wiley; and on Acquaintanceship, Dr. W. F. M. Goss. This last committee met on board ship on Saturday evening and arranged for the introduction of the members of the party to one another.

It is a matter of much regret that President Westinghouse was at the last moment prevented from attending the meetings, which in his absence will be presided over by W. F. M. Goss and Charles Whiting Baker, Vice-Presidents.

A running account of the meeting will be prepared by Calvin W. Rice, Secretary of the Society, for publication in the fall.

The party on the Celtic is to be joined in England by other members and guests now in Europe or going by other routes, and the total number cannot be announced until the final registration at the meetings in England. Following is a list of those sailing on the Celtic:

Adams, Miss, New York, with Hon. and Mrs. Wm. H. Wiley
Aldrich, John G., Providence, R. I.
Alford, L. P. New York
Alford, Mrs., New York
Armstrong, Miss, Elizabeth N. J., with Mr. and Mrs. S. L. Moore
Baldwin, Abram T., Detroit, Mich.
Barnes, Howel H., Jr., New York
Bevin, Sydney, Walden, New York
Bevin, Mrs., Walden, New York
Brill, Geo. M., Chicago, Ill.
Brill, Mrs., Chicago, Ill.
Brill, Elliot M., Chicago, Ill.
Brill, G. Meredith, Chicago, Ill.
Brooks, J. Ansel, Providence, R. I.
Bump, Burton N., Syracuse, N. Y.
Bump, Mrs., Syracuse, N. Y.
Burlingame, L. D., Providence, R. I.
Burlingame, Mrs., Providence, R. I.
Burlingame, Miss, Providence, R. I.
Bursley, Jos. A., Ann Arbor, Mich.
Bursley, Mrs., Ann Arbor, Mich.
Calder, John, Ilion, N. Y.
Calder, Mrs., Ilion, N. Y.
Camp, Geo. E., Utica, N. Y.
Clarke, C. W. E., New York
Cobleigh, H. R., New York
Coffin, Mrs., Charles H., New York with Mr. and Mrs. Jesse M. Smith
Colwell, Augustus W., Columbus, O.
Corbett, Charles H., Brooklyn, N. Y.
Corbett, Mrs., Brooklyn, N. Y.
Dart, Wm. C., Providence, R. I.

Davis, Chas. Ethan, Muncie, Ind.
Davis, Mrs., Muncie, Ind.
Dean, F. W., Boston, Mass.
Dodge, James M., Past-Pres., Philadelphia, Pa.
Dodge, Mrs., Philadelphia, Pa.
Dodge, Miss, Philadelphia, Pa.
Dodge, Karl, Philadelphia, Pa.
Durfee, Walter C., Jamaica Plain, Mass.
Durfee, Miss, Jamaica Plain, Mass.
Foster, Miss, New York, with Mr. and Mrs. Augustus Smith
Freeman, John R., Past-Pres., Providence, R. I.
Freeman, Mrs., Providence, R. I.
Galloupe, Francis E., Boston, Mass.
Galloupe, Chauncy Adams, Boston, Mass.
Gantt, H. L., Manager, New York
Gantt, Mrs., New York
Gleason, Wm., Rochester, N. Y.
Goss, W. F. M., Vice-Pres., Urbana, Ill.
Goss, Mrs., Urbana, Ill.
Goss, Miss, Urbana, Ill.
Greene, Arthur M., Jr., Troy, N. Y.
Greene, Mrs., Troy, N. Y.
Hallenbeck, Geo. E., Toledo, Ohio
Hamilton, Chester B., Jr., Toronto, Can.
Hartness, James, Manager, Springfield, Vt.
Hartness, Mrs., Springfield, Vt.
Hartness, Miss, Springfield, Vt.
Hartness, Miss Helen E., Springfield, Vt.
Higgins, C. P., Roselle, N. J.
Higgins, Mrs. Roselle, N. J.
Hillyer, Geo., Jr., Atlanta, Ga.
Honsberg, August A., Cleveland, Ohio
Hutton, F. R., Past-Pres., Hon. Secy., New York
Hutton, Mrs., New York
Johnson, A. L., Muncie, Ind.
Johnson, Mrs., Muncie, Ind.
Keep, W. J., Detroit, Mich.
Keep, Mrs., Detroit, Mich.
Keep, Miss, Detroit, Mich.
Klepinger, J. H., Great Falls, Mont.
Klepinger, Mrs., Great Falls, Mont.
Klock, Frank B., Syracuse, N. Y.
Latham, H. M. Worcester, Mass.
Leland, Henry M., Detroit, Mich.
Leland, Mrs., Detroit, Mich.
Lewis, Wilfred, Philadelphia, Pa.
Lodge, William, Cincinnati, Ohio
Lodge, Mrs., Cincinnati, Ohio.
Low, F. R., New York
Low, Mrs., New York
McCreery, J. H., New York
Main, Charles T., Boston, Mass.
Main, Mrs., Boston, Mass.
Main, Miss, Boston, Mass.
Main, Theodore, Boston, Mass.
Marburg, L. C., New York
Miller, Spencer, New York
Miller, Spencer, Jr., New York
Moore, S. L., Elizabeth, N. J.
Moore, Mrs., Elizabeth, N. J.
Morrin, Thos., San Francisco, Cal.
Morrin, Mrs., San Francisco, Cal.
Nelson, James W., New York
O'Neil, J. G., Chicago, Ill.
O'Neil, Mrs., Chicago, Ill.
Orrok, Geo. A., New York
Parson, Charles H., New York
Parson, Mrs., New York
Phalen, Miss, niece of Wm. Gleason, Rochester, N. Y.
Platt, John, New York
Plunkett, Charles T., Adams, Mass.
Plunkett, Chas. T., Jr., Adams, Mass,
Reed, E. Howard, Worcester, Mass.
Reed, Mrs., Worcester, Mass.
Reid, Joseph, Oil City, Pa.
Rice, Calvin W., Secretary, New York
Richmond, Knight C., Providence, R. I.
Roe, J. W., New Haven, Conn.
Sague, J. E., Albany, N. Y.
Sague, Mrs., Albany, N. Y.
Sague, Miss, Albany, N. Y.
Sanford, Geo. R., Syracuse, N. Y.
Smith, A. Parker, New York
Smith, Mrs., New York
Smith, Augustus, New York
Smith, Mrs., New York
Smith, Jesse M., Past-Pres., New York
Smith, Mrs., New York
Smith, Oberlin, Past Pres., Bridgeton, N. J.
Smith, Mrs., Bridgeton, N. J.
Stillman, F. H., New York
Stillman, Mrs., New York
Struckmann, H., St. Louis, Mo.
Struckmann, Mrs., St. Louis, Mo.
Such, Miss, New York, with Mr. and Mrs. Augustus Smith
Swasey, Ambrose, Past-Pres., Cleveland, Ohio
Swasey, Mrs., Cleveland, Ohio
Thompson, B. L., Syracuse, N. Y.
Thurston, Edw. D., Jr., New York
Thurston, Mrs., New York
Turner, Charles P., New York
Upp, John W., Schenectady, N. Y.
Upp, Mrs., Schenectady, N. Y.
Upp, John W., Jr., Schenectady, N. Y.
Waldo, Leonard, New York
Warner, Worcester R., Past-Pres., Cleveland, Ohio

Warner, Mrs., Cleveland, Ohio
Watson, William, Boston, Mass.
Wells, F. O., Greenfield, Mass.
Wells, Mrs., Greenfield, Mass.
Wells, Miss, Greenfield, Mass.
Wheeler, Seth, Albany, N. Y.
Wheeler, Mrs., Albany, N. Y.
Wiley, Wm. H., Treasurer, New York
Wiley, Mrs., New York
York, L. D., Porthsmouth Ohio
York, Robert, Memphis, Tenn.

NECROLOGY

MARK BARY

Mark Bary, Associate Member of the Society, who died December 27, 1909, was born at Detroit, Mich., on June 27, 1873.

Immediately after his graduation from the University of Michigan in the class of 1897, Mr. Bary entered the employ of the Michigan Electric Company, as assistant, and later in the same year was engaged as instrument man with the Missouri River Company. For the next two years Mr. Bary was employed by Bryan and Humphrey as assistant in electrical and mechanical work and as superintendent in their office. In March 1900 he became engineer-in-charge of the Laclede Power Company at St. Louis, Mo., and later in the same year engineer of construction of the city lighting plant of the Imperial Electric Light Company, St. Louis. In 1901 Mr. Bary became first assistant to H. H. Humphreys, consulting engineer, his chief work being the mechanical design and superintendence of installation of electrical and mechanical power plants. From 1904 to 1907 he was engaged in consulting practice under his own name in St. Louis.

Mr. Bary was a member of the St. Louis Society of Civil Engineers and the Disraeli Society of St. Louis. He entered The American Society of Mechanical Engineers in 1903.

RALPH WALDO EMERSON

Ralph Waldo Emerson, Associate Member of the Society, was born at Orland, Me., March 18, 1872, and received his early education at the country schools and the Phillips Andover Academy. In 1890 he entered the Worcester Polytechnic Institute where he received his technical training, leaving there in 1893 before graduation, to serve an apprenticeship with Brown and Sharpe of Providence, R. I. He remained here for two years and was subsequently connected with the American Wheelock Engine Company and the Norton Emery Wheel Company. In 1898 Mr. Emerson accepted a position as draftsman with the Cereal Machine Company of Worchester, Mass.,

known later as the Shredded Wheat Company and was responsible for much of the special machinery. When the company moved to Niagara Falls, he took charge of the layout and equipment of the plant, and from draftsman rose to the position of mechanical engineer. In 1904 he became Master Mechanic of the Case Factory of the Singer Manufacturing Company, South Bend, Ind., with which company Mr. Emerson was connected until some six months ago when, as mechanical engineer and factory economist, he opened an office of his own.

In coöperation with Frank Bishop, Mem. Am.Soc.M.E., Mr. Emerson invented and patented a refrigerating machine for domestic use.

Mr. Emerson was a member of the Commercial-Athletic Club of South Bend.

THOMAS H. SAVERY

Thomas H. Savery was born in Philadelphia, Pa., on May 31, 1837, and died at his home in Wilmington, Del., April 5, 1910. He was educated at the Westown Boarding School and later at Friends' Select School, Philadelphia. When sixteen years of age he was apprenticed as a machinist to William Sellers and Company of Philadelphia, with which firm he remained for five years, becoming at the completion of his term of service general foreman of the Columbus machine shops of the Columbus, Piqua and Indianapolis Railroad, and later foreman of the Altoona shops of the Pennsylvania Railroad. In January 1864, he accepted a position as superintendent of Pusey and Jones Company of Wilmington, Del., was admitted as a partner, and was connected with the company as vice-president and then as president until his retirement in 1907 from active service. Mr. Savery was chiefly interested in the development of paper machinery and it was through his efforts and inventions that the Pusey and Jones Company became the acknowledged leaders in building paper machinery.

At the time of his death he was president of the Harpers Ferry Paper Company, the Shenandoah Pulp Company and the Harpers Ferry Electric Light and Power Company. He was also a director in numerous other companies in Wilmington, Philadelphia and other cities.

WM. P. BETTENDORF

Wm. P. Bettendorf was born in Mendota, Ill., July 1, 1857, and died at his home in Bettendorf, Iowa, on June 3, 1910.

His career as a mechanic and inventor began with the termination of his apprenticeship as machinist in the Peru Plow Company, Peru, Ill., in 1878. The following three or four years were devoted to the design and manufacture of farm implements at Moline and Canton, Ill. In 1882 he returned to Peru, accepting a position as superintendent of the Peru Plow Company and shortly afterward invented the now famous Bettendorf metal wheel, still used in fully ninety per cent of the agricultural implements made in the west. He also designed the full line of special machinery for the manufacture of steel wheels, from a wheelbarrow wheel to a grain harvester.

The Peru Plow Company being very limited in capital and manufacturing capacity, Mr. Bettendorf organized the Bettendorf Metal Wheel Company at Davenport, Iowa. With this company he severed his connections in 1891 and turned his attention to designing an all-steel running gear for farm wagons. This task, seemingly simple, but in reality of prodigious proportions, led him into hydraulics and intricate die-working before its final accomplishment. The gear was made entirely of sheet steel pressed into shape by special hydraulic presses and elaborate dies, and was the first with a tapering spindle to accomodate any size standard wood wagon wheel.

While perfecting the steel wagon gear, it occurred to Mr. Bettendorf that the ordinary truck for freight cars could be greatly simplified, the number of parts and weights reduced and the strength increased. His efforts along these lines resulted in the Bettendorf brake beam, pressed from sheet steel similar to the axles of the steel wagon gear. That which will prove an enduring monument to his memory as a car builder is the design of steel underframing for freight cars and the highly advanced methods for its manufacture.

Mr. Bettendorf became a member of the Society in 1895. He was also a member of the Western Railway Club, the New York Railway Club, the Railway Club of Pittsburg, the Eastern Railway Club, the New York Mechanical Club, the American Foundrymens Association, the Union League Club, and the Chicago Athletic Association.

CHARLES FREDERICK FOSTER

Charles Frederick Foster was born in Boston, Mass., September 28, 1852. He was educated in the public schools of Boston and the Punchard Free School of Andover, Mass., from which he was graduated in 1869. At the age of seventeen he began his engineering career as rodman, then as leveler and transitman in the office of the City

Engineer of Boston, where he remained until 1872. The next three years were spent with the Lowell and Andover Railroad and in the Water Works of Lawrence, Mass. Subsequent to this he became an assistant to Walter McConnell in general engineering in and around Boston; and from 1876 to 1880 occupied the position of mechanical engineer and superintendent of the St. Louis Cotton Factory. In 1873 he became assistant engineer of the Heine Safety Boiler Company. In 1893 Mr. Foster was identified with the World's Columbian Exposition at Chicago, and it was due to his excellent work and energy that the task of construction was completed in time and the fair opened on the date set. He was also connected with the International Exposition, Atlanta, Ga., as mechanical and electrical engineer and with the Universal Exposition at St. Louis, Mo., held in 1904, as chief operating engineer.

In 1905, he returned to Chicago and resumed his private practice, devoting his spare time to the compilation of engineering data which unfortunately his sudden death on May 8 left unfinished.

Mr. Foster was a member of the Western Society of Engineers and the Engineers Club of St. Louis. He became a member of The American Society of Mechanical Engineers in 1890.

The Western Society of Engineers records in its minutes: "Mr. Foster will be best remembered for his wonderful power of thought concentration; his indomitable energy; his deductive mind; his mastery of detail; his executive ability; his skill in handling large bodies of men and molding them into a concrete, harmonious, forceful working unit; his connection with various universal expositions; and by his intimates for his lovable character and amiable disposition."

THE MECHANICAL ENGINEER AND THE TEXTILE INDUSTRY

By H. L. Gantt, Published in The Journal for May

The following addition to his paper was given orally by Mr. Gantt in presenting it before the Society at the Spring Meeting and should therefore be considered a part of the paper.—Editor.

20 It has been stated that the colleges are turning out power plant engineers. Professor Rautenstrauch in his paper really makes a plea for the mechanical engineer to broaden his field, and it is my experience also, that the mechanical engineer in school lays a great deal of stress on the power plant engineer, often to the comparative neglect of the engineer engaged in other industrial enterprises. The field of the mechanical engineer today seems to be industrial. He is needed in all kinds of industries. Up to this time his attention has been confined largely to the power portion, and almost exclusively to the metal working portion of our industry.

21 By accident, having always been engaged in the metal working industry until a few years ago, I got into the textile industry, and am also familiar with some other industries, and I am satisfied that the field for the mechanical engineer in the non-metal working industries is as large, if not far larger than the metal working industries, since the latter have been developed to a much higher state of perfection than the former.

22 At a meeting of the National Metal Trades Association in New York at which I was present, statistics were given as to the decreasing cost of production of machines of various kinds. Those in attendance were largely engineers and manufacturers, whose business it is to manufacture cheaply, and who were interested in effecting shop economies. Shortly afterwards I read a paper in Boston before the Cotton Manufacturers' Association of New England and there I found comparatively few people who were familiar with the details of their shop. They were more skilful as merchants, for the high price of their raw materials, cotton, for instance, was such as to make the buying and selling end of their business much more important in their eyes than the actual process of manufacturing. The best talent was de-

voted to the buying and selling end and they knew but little about the details of manufacture in many cases.

23 Until the average cotton mill owner comes to the conclusion that something more is needed to make a manufacturer than a classical education, this situation will continue. The value of the mechanical engineer in this field has not yet been realized.

TEST OF A 15,000-KW. STEAM-ENGINE-TURBINE UNIT

By H. G. Stott and R. J. S. Pigott[1], New York, Published in The Journal for March 1910

ABSTRACT OF PAPER

This paper relates to the installation of low-pressure turbines at the 59th Street station of the Interborough Rapid Transit Company, New York, originally equipped with engines of the Manhattan type, which are double engines having a 42-in. horizontal high-pressure cylinder and an 86-in. vertical low-pressure cylinder with a 5000-kw. generator. The generator is capable of carrying a load of 8000 kw. continuously, but the best economy is obtained at about 5000 kw. In considering the means for increasing the power of the station, it was finally decided to add low-pressure turbines to operate on exhaust steam from the engines. Three turbines have been installed of the vertical, 3-stage, impulse type, having six fixed nozzles and six which can be operated by hand, so as to control the back pressure on the engine over the division of load between engine and turbine. The turbines drive generators of the 3-phase induction type of 7500-kw. normal capacity. By the addition of the turbine the engine can be run to the full capacity of its generator, to which is added the current from the turbo-generator, making a total output of 15,000 kw. The net results obtained by the installation, as indicated by the tests reported in the paper are summarized as follows:

a An increase of 100 per cent in maximum capacity of plant.

b An increase of 146 per cent in economic capacity of plant.

c A saving of approximately 85 per cent of the condensed steam for return to the boilers.

d An average improvement in economy of 13 per cent over the best high-pressure turbine results.

e An average improvement in economy of 25 per cent (between the limits of 7,000 kw. and 15,000 kw.) over the results obtained by the engine units alone.

f An average thermal for the unit efficiency between the limits of 6500 kw. and 15,500 kw. of 20.6 per cent.

ADDITION TO PAPER

The following addition to the paper was given orally by Mr. Pigott in presenting it before the Society at its meeting in New York in March, and should therefore be considered a part of the paper.—Editor.

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[1] Assistant Engineer, Fifty-Ninth Street Station of the Interborough Rapid Transit Company.

25 The first point which presents itself in view of the remarkable results of these tests, is the question of accuracy of measurement. The actual unit water-rate is dependent upon three factors only: quality of steam entering the engine, kw. load, and weight of water per hour. The quality of high-pressure steam is easily and accurately determined by means of the ordinary throttling calorimeter. The load on the machines was determined by means of nine integrating meters: two meters each on turbine, engine and total load, connected by the 2-meter method; one balanced 3-phase meter each on turbine, engine, and total load. Each meter was calibrated once a week, and the error was always within one-half of 1 per cent.

26 The weight of water from the turbine hot-well was determined by a pair of 40,000-lb. standard platform scales, with a recording device in addition to the hand weighing. The load was about 25,000 lb. per scale, the limitation being the size of the tanks on the scales. These scales are graduated to 5 lb. and will balance to 2 or 3 lb., so that the error in reading is negligible. Receiver trap water and low-pressure separator water were weighed together on a pair of 2000-lb. platform scales, reading to $\frac{1}{2}$ lb. All scales were calibrated with standard 50-lb. weights before testing.

27 The actual trap water weight was obtained by interposing a 1-in. Venturi meter with recording device in the line to the scales; this was also calibrated by scales and found correct to less than 1 per cent, and the low-pressure separator water obtained by difference.

28 For examination of thermodynamic conditions within the machines, the most important determination is that of quality of the low-pressure steam to the turbine, since on this depends one of the important corrections to guaranteed conditions. There were no experimental data available that we could discover, bearing on low-pressure quality determinations, so the investigation was made incidental to the tests, from which the following was established. The ordinary standard perforated pipe sampler is absolutely worthless in giving a true sample, and it is vital that the sample be abstracted from the main without changing its direction or velocity until it is safely in the sample pipe and entirely isolated from the rest of the steam. Multiple orifice nozzles are of no use, as in all cases one orifice will supply practically all the steam, leaving the others useless. After much experimenting with various styles of samples, all of which were failures, the single orifice curved tube (Fig. 34) was adopted.

29 The reason for failure of other styles is plain; if any sudden turn is made by the wet steam in entering the sample nozzle, the

entrained moisture, by reason of its immensely greater specific gravity and slight skin friction in the tenuous surrounding fluid, will continue with unchanged direction and a dry sample will enter the nozzle. In

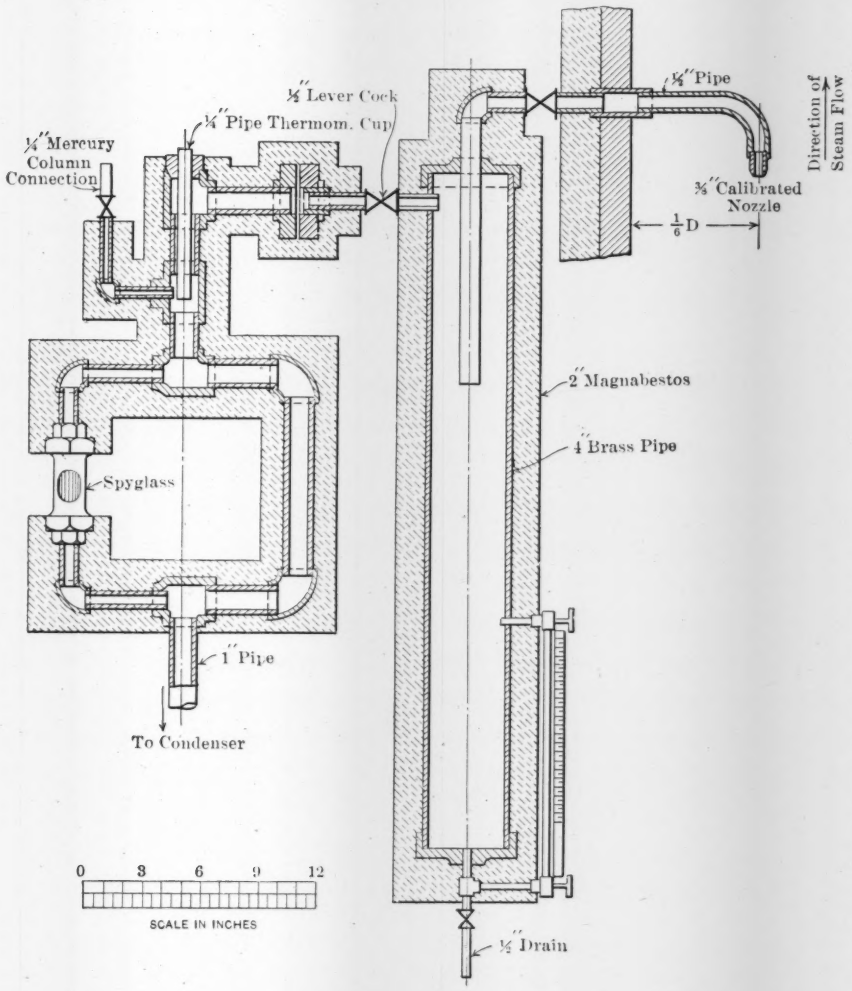

FIG. 3 LOW-PRESSURE SEPARATING-THROTTLING CALORIMETER

other words, the sampler becomes a very fair separator. Again, if the velocity in the sampler is greater than that in the main, even though there be no separating action with the proper sampler, the

steam will accelerate into the nozzle, and the moisture will not, giving a dry sample; and the reverse is true if the velocity is less in the sampling nozzle than in the main. The reason this very simple action has not been noted in connection with high-pressure steam is the smaller difference in specific gravity of water and steam, the enormously greater skin friction and the small percentage and highly-divided state of the moisture present.

30 The successful types of calorimeter for very wet steam were the Thomas electric, and a combination of a separating calorimeter with a throttling calorimeter. By the use of the separating calorimeter most of the moisture was removed, and the small remainder was registered by the throttling calorimeter. At first glance it seems as if, with an initial pressure of 12 lb. to 20 lb. absolute, the throttling calorimeter has no capacity, but by putting a vacuum of 28 in. on the discharge side of the calorimeter, an available heat is obtained sufficient to evaporate 2 or 3 per cent of moisture. When the moisture became less than this, we used the throttling calorimeter direct, eliminating the separating calorimeter altogether. The separating-throttling combination was afterward tested for radiation loss and found to lose less than 0.1 per cent at proper flow. Fig. 34 shows this combination instrument. The large size is necessary on account of the very high specific volume of steam at low pressure.

31 Referring to Fig. 34, the $\frac{3}{8}$-in. brass nozzle on the sampler is arranged to point in exactly the opposite direction to the steam flow; the lip of the nozzle is filed to a knife-edge to avoid disturbing the steam current around the sampler mouth by impact and eddies against a sensibly thick lip. The diameter of the brass nozzle is carefully measured and, if necessary, reamed smooth. This form of sampler fulfills the requirements noted above; it takes out the sample without disturbing its direction, by virtue of its position and knife-edged orifice, and the velocity can be kept correct by determining the flow from the following simple formula:

$$w = \frac{Wa}{A}$$

where

w = lb. per hr. flow through calorimeter.
W = lb. per hr. flow through steam main
a = area of sampler nozzle
A = area of main.

The sampler is allowed to extend into the pipe one-sixth of the pipe diameter, which has been found to give practically true average flow.

32 The ½-in. valve at the sampler is opened wide, and the ½-in. lever cock between separating and throttling calorimeters is used to regulate the flow, the throttling action taking place at this point. The rest of the calorimeter is under vacuum, the discharge being connected to a small cooler to condense the steam and then to a volumetric measuring tank. The top of this tank, which is entirely closed except for the pipe connections, was connected with the turbine condenser by a ¼-in. pipe, which gave an available vacuum of over 28 in. without affecting the measuring in any way. The spy-glass is very useful in proving that the calorimeter is working properly, for when the superheat in the throttling calorimeter gets below 6 or 8 deg. it sometimes happens that some moisture goes by, in which case the spy-glass immediately shows it up, no matter how small the quantity. As the spy-glass is most conveniently made of ¾-in. gage glass, more area is required to take away the steam from the calorimeter, and this was done by adding a by-pass of 1-in. pipe around the spy-glass. This allows free flow to take place and does not affect the function of the glass.

33 The percentage of moisture taken out by the separating portion of the instrument divided by the total percentage of moisture gives the efficiency of the separating calorimeter, which turns out to be much lower than is ordinarily supposed, from 60 to 80 per cent.

34 For the rest of the measurements steam pressures throughout were taken with high-grade thermometers, graduated to 1 deg. and in many cases as low as 0.2 deg., as these are in every case preferable to gages for saturated steam. All pressures below 15 lb. gage and all vacua were measured by mercury column, in addition to temperatures.

35 Table 1, Steam to Auxiliaries, includes for tests 25, 22, 24, 21, 23 and 26, the circulating water pump steam only; test 27, circulating water pump and dry vacuum pump; test 29, circulating water pump, dry vacuum pump and boiler feed pump; test 30, boiler feed pump alone.

36 Fig. 11 and Fig. 11a show variation of points is due to errors in earlier low-pressure calorimetry, before the standard instruments were settled upon.

37 Table 12, the column of Unit Water-Rate Total Correction, is based on a standard vacuum of 28.72 in. instead of 28.5 in., as the higher figure was the average vacuum of the series of tests. Consequently the absolute amount of correction was reduced, which is of course very desirable, in view of the uncertainty of correction factors.

38 In Fig. 14 these water rates are uncorrected for moisture, etc.

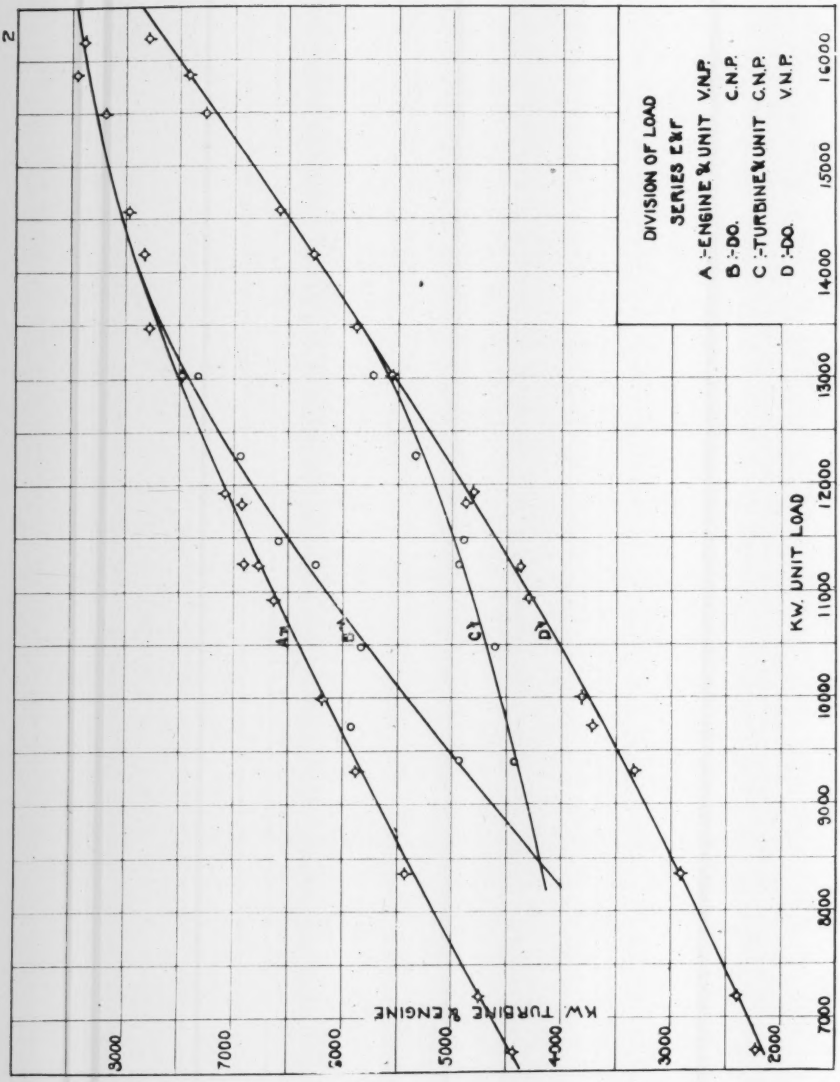

FIG. 35 DIVISION OF LOAD. SERIES E AND F

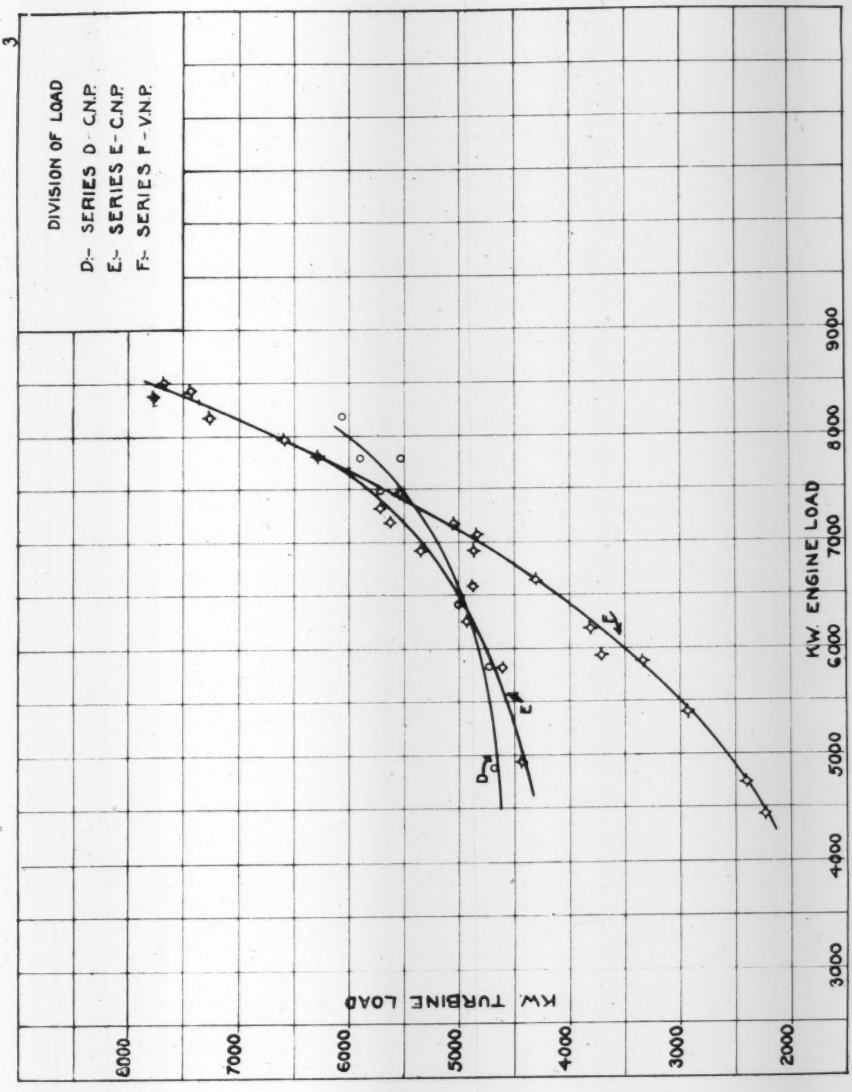

FIG. 36 DIVISION OF LOAD. SERIES D, E AND F

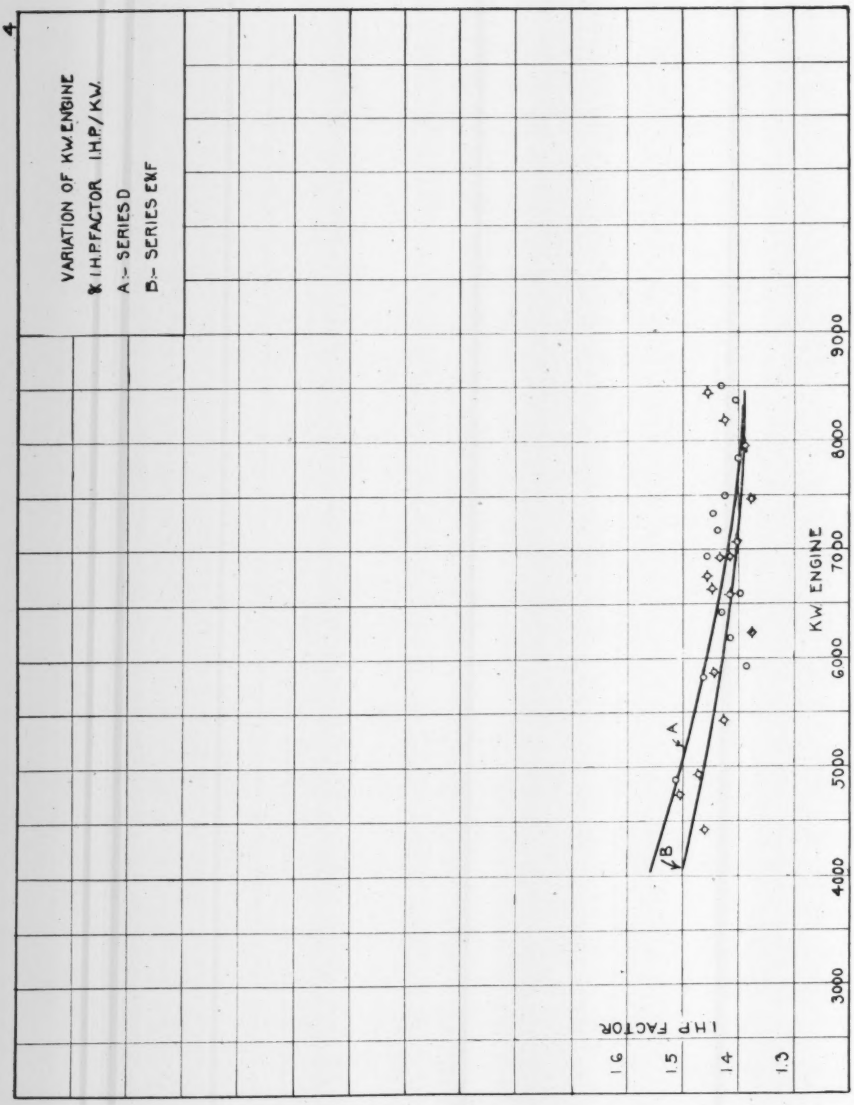

FIG. 37 VARIATION OF KW.-ENGINE AND I.H.P. FACTOR

39 In Fig. 32 the calorimeters were drawn for the sake of clearness, as if they were situated at some distance from the sampling points; actually they were, as in Fig. 1.

40 Figs. 35, 36 and 37 serve to show the variation in load between engine and turbine, and the effect of change of efficiency of the two machines.

DISCUSSION[1]

W. L. R. EMMET. While some few applications of low-pressure turbines in connection with electric-generating engines have been put into operation before that which is described in this paper, such cases are relatively unimportant and I think that in all of them the application has been made to a station which was formerly operated non-condensing.

2 In recent years the science of steam engineering has advanced very rapidly and as the cost of fuel has increased the cost of apparatus has diminished so that we now find ourselves in a position where the question of investment is of much less relative importance than formerly, the value of the product being so very large in proportion to the cost of the apparatus required. For this reason we generally cannot afford to use any apparatus but the best, no matter how great its cost.

3. The operation of stations by turbines alone is simpler and generally more economical than that of stations which use reciprocating engines and there are many cases where it might be better to install high-pressure turbines instead of coupling low-pressure turbines with existing reciprocating engines. The results shown by Mr. Stott's paper, however, should demonstrate to many station managers that they cannot afford to run reciprocating engines alone when such an improvement can be accomplished by the addition of low-pressure

[1] During the installation and tests of the low-pressure turbines at the 59th Street station of the Interborough Rapid Transit Company, described in the above paper, a meeting of the Society was held in Boston, November 17, 1909, addressed informally by H. G. Stott on the subject of the installation. This was followed by a topical discussion on low-pressure steam turbines. On March 8, 1910, Mr. Stott and Mr. Pigott gave a complete account of the installation and tests and in what follows the discussion at both of these meetings has been combined. There has been added also an abstract of a discussion on steam turbines given at a meeting of the Society and the Engineers Club of St. Louis, in St. Louis, December 11, 1909, by G. R. Parker, Assoc.Mem.A.I.E.E.

turbines. I regret that Mr. Stott has not dwelt at more length upon the saving in investment and operation which has been effected by this installation, although his tests and explanations afford most of the data necessary for such comparisons. The increase of firing capacity due to the changes made in many of the boilers sometime ago has also contributed greatly to the remarkable improvement in this plant. Comparisons of the original conditions with the ultimate development of the present plan afford a very striking example of what can sometimes be done with an old station.

4 The results in steam consumption shown by Mr. Stott's tests are very decidedly better than the best results which have ever been accomplished with turbines alone, the advantage in water rate amounting to about 2 lb. per kw-hr. as compared with the best turbine results. When it is possible that this station will never produce power commercially more cheaply than the best modern turbine stations are now doing with equal fuel, the great value of this installation will be apparent when the enormous investment saving is considered.

5 Some of the curves given in the paper would seem to indicate that the results accomplished by the turbines were inferior to those guaranteed or expected, whereas in fact all guarantees and expectations have been rather exceeded. The reason for this apparent discrepancy is that Mr. Stott has not made allowance for the losses introduced by the presence of moisture in steam entering the turbines, whereas the guarantees on the turbines were based upon dry steam. Mr. Stott has reported the facts as they exist and as they are influenced by such methods of moisture separation as he has used. If the separation were more perfect the turbine results as shown by the curves would be much better and it is probable that with more experience, an almost complete absence of moisture in the turbine steam can be provided for. In Schenectady, where we are operating two large low-pressure turbines on exhaust steam from a reciprocating engine plant, we are running with steam which is almost completely dry. The reason for this is that the steam has to pass horizontally through a long pipe which ends in a separator and is drained before it reaches the separator. This arrangement gives the steam ample time to throw down its moisture and the last vestige of it is taken by the separator. In most applications of low-pressure turbines and engines, such an arrangement can be provided for, while in the installation referred to in this paper the delivery of steam from engine

to turbine is in a downward direction and through very short pipes in which little separation or collection of moisture into drops can occur.

MAX ROTTER. The success of an enterprise of such magnitude and novelty required, on the part of those responsible for it, a very considerable courage and confidence in engineering calculations. The test results and Mr. Stott's deductions from them will exercise no small influence on all who are interested in the production of power on a large scale.

2 One matter of practical interest is the elimination of the moisture and oil from the steam, during its passage from the engine exhaust to the turbine inlet. Tests 45 to 62 seem to show that the moisture remaining in the steam, as it entered the turbine, amounted to an average of over 4 per cent. Can it be assumed that this may be reduced to zero without re-heating or increased pressure drop? If not, then the inefficiency of the separation must be considered as one of the losses inevitable in an installation of this kind, and corrections for moisture entering the turbine should properly be omitted, as such losses would be on a par with the losses in the low-pressure stages of a high-pressure turbine, due to the water of liquefaction delivered to them from the high-pressure stages. It is not the same as a correction for moisture in the steam as originally delivered to the engine, for the engine and low-pressure turbine, with their necessary connecting elements, must be considered as a single unit and it is proper to correct only for conditions due to the imperfection of external apparatus serving the unit. For instance, while a correction for moisture in the steam would be made in testing an engine as a unital piece of apparatus, no such correction would be made in testing, as a unit, the complete plant of such engine and its boilers. The correction of 1 per cent in consumption per 1 per cent of moisture delivered to the turbine is the usual full allowance for the internal losses caused by such moisture; as obviously no deduction of the moisture itself can be made, this having been already allowed for in determining the dry steam delivered to the engine. This correction of 1 per cent is thus equivalent to the customary correction of 2 per cent in consumption per 1 per cent of moisture, as applied to a high-pressure turbine performance. The elimination of oil is probably more important as affecting the maintenance of the efficiency of the turbine and surface condenser than that of the boilers.

3 One of the most interesting features of the paper is the comparison of this engine and low-pressure turbine installation with an in-

stallation of high-pressure turbines. It is not clear whether the high-pressure turbine referred to by Mr. Stott is one of a capacity equivalent to that of the low-pressure turbine only, or to that of the combined engine and low-pressure turbine unit. The latter would certainly be proper and seems to be that considered by Mr. Stott in his statements regarding relative costs (Par. 11); but the high-pressure turbine efficiencies stated in Par. 24*d* and Fig. 19*a*, Series E and F, are apparently those of a considerably smaller machine. Nor is it quite proper to compare the efficiencies of two units on the basis of the test performance of one as against the guaranteed efficiencies of the other. A business man will not guarantee more than necessary, nor will he guarantee under any circumstances the best he can hope to do under test. Furthermore, a slight change in operating conditions might materially affect such a comparison. For instance, the majority of modern high-pressure turbine plants operate with some superheat, of which the high-pressure turbine can take greater advantage than can the engine and low-pressure turbine unit. The frequency of the turbo-alternator, in so far as it determines the speed of the turbine, will also exercise some influence upon the results. At the 59th Street station the slow speed of 750 r.p.m. is somewhat unfavorable to the turbine. A higher turbine speed would, in the case of the engine and low-pressure turbine unit, increase the efficiency of the turbine only; that is, the improvement in efficiency would apply to only about one-half of the total load of the unit; whereas, in the case of a high-pressure turbine of a capacity equivalent to that of the combined unit, the improvement in efficiency would apply to the full output of the machine. The comparative operating expenses must also be considered, and these are unquestionably lower for the high-pressure turbine than for the combined unit.

4 For the purpose of comparing the steam consumptions of the two types of apparatus, the final results given in Table 12, Series E and F, have been replotted herewith on Fig. 1 and curve A drawn through the points. This curve therefore shows the steam consumption of the combined unit, corrected to dry saturated steam at the engine throttle at 180 lb. gage, dry saturated steam at the low-pressure turbine throttle at variable pressure, and a vacuum equivalent to 28½ in. referred to a 29.92 in. barometer. Curve B refers to a high-pressure turbine unit operating with dry saturated steam at 180 lb. gage and a vacuum of 28½ in. referred to a 29.92 in. barometer, at a speed of 750 r.p.m., and having a capacity about equivalent to that of the combined engine-low-pressure-turbine unit. This latter curve

shows the steam consumptions it would be perfectly safe to expect from such unit under test, and it is probable that a consumption 0.3 to 0.4 of a pound lower would be attained. In making guarantees, from 1 to 1½ lb. per kw-hr. would be added. A comparison of these curves would indicate that the average difference of 8 per cent as given by Mr. Stott in Par. 14 is ample, and 13 per cent as given by him in Par. 24*d* too high.

5 To indicate the effect of a change in operating conditions, curves A and B (Fig. 2 herewith) have been plotted to show the performance of the units when operating under the conditions above mentioned, except that the steam is superheated 100 deg. fahr. It will be noted that the advantage of the combination as against the single unit is materially lowered.

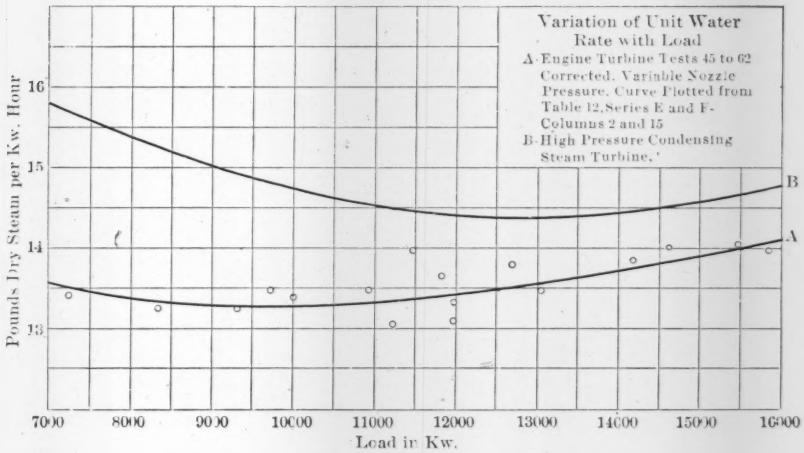

FIG. 1 RESULTS IN TABLE 12, SERIES E AND F

6 That the high-pressure turbine consumptions, as shown by the curves, are reasonable is proved by a recent unassailable test of this type of turbine, with steam at 180 lb. gage, superheated 100 deg. fahr., and a vacuum of 28¼ in. referred to a 29.92 in. barometer, which showed a consumption of 14.02 lb. per kw-hr.; the turbine having a normal capacity of only 4000 kw. at 1800 r.p.m.

7 An improvement in efficiency of 13 per cent in the 59th Street plant would almost seem to warrant a combined engine and low-pressure turbine unit as an initial installation, and it would be interesting to learn whether Mr. Stott would consider such an installation for

extensions of this plant beyond the capacity obtainable by adding low-pressure turbines to all of the existing engines.

8 The conditions for which low-pressure turbines are being considered have multiplied much faster than anticipated. For instance it has been proposed to operate a turbine by means of steam from natural geysers, which is perfectly feasible. The steam would be obtained by passing the hot water through vessels in which a pressure drop would take place and part of the water be evaporated. With such an arrangement it would be necessary to handle 30 to 50 lb. of water to obtain 1 lb. of steam at a pressure slightly below atmosphere.

9 Another use for low-pressure turbines is that of generating power from hitherto wasted industrial steam. For instance, a tur-

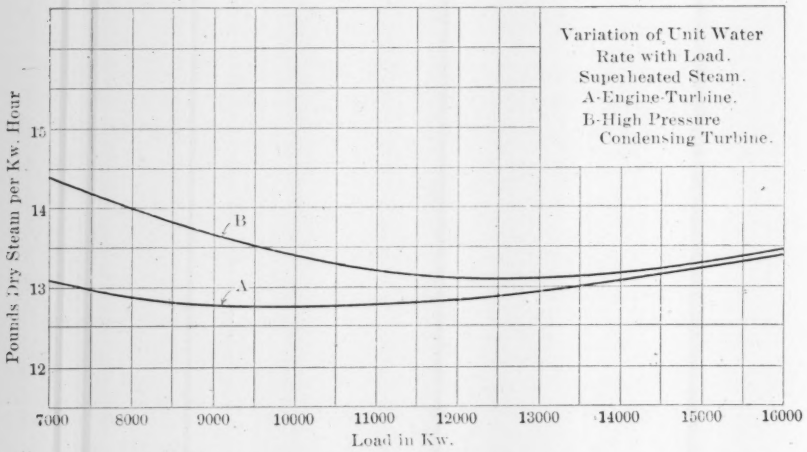

FIG. 2 CURVES A AND B, SHOWING PERFORMANCE OF UNITS WHEN OPERATING UNDER GIVEN CONDITIONS

bine is now being installed in an automobile tire factory where the retorts used for vulcanizing are filled with high-pressure steam for a certain period, the major portion of this steam being then blown out into the air before the retorts are opened for re-charging. This steam will henceforth be collected in a receiver, in which its pressure will drop approximately to atmospheric, and from which it will be delivered to a low-pressure turbine for use. The supply of steam is almost constant and will generate 1000 to 1200 kw., the only cost being the fixed charges, labor, and the water required for condensing.

10 Every improved method or appliance is exposed to the danger of being retarded in the progress it really merits by a few ill-advised

applications, and there are conditions under which it would be better not to advocate low-pressure turbines as additions to reciprocating engines. In almost all instances figures will show a saving of steam as achievable by such combination, but the cost of power production in a great many industrial plants is so small an item compared with the other expenses, that a reduction of even 25 per cent in fuel consumption is frequently insignificant when weighed against other considerations.

11 A low-pressure turbine should not be installed where its steam supply depends upon an old and unreliably decrepit engine. The proper thing here is an independent high-pressure condensing turbine. And as a high-pressure condensing turbine of the same capacity as the engine and low-pressure turbine combined will give so nearly the same efficiency as the combination, the boilers and the condensing apparatus will cost about the same for either installation, the fuel consumption will be about the same, and the engine can be set aside for emergency use.

12 There are numerous instances where compound engines are not overloaded but underloaded. Many of them are running non-condensing and it is a condenser and not a low-pressure turbine that is needed. The beneficial effect of adding a condenser to an underloaded compound engine is twofold: firstly, it will lower the mean effective pressure at which the engine attains its best efficiency and, therefore, if the engine is underloaded, it will bring the point of best efficiency nearer the running load; and secondly, there is the increased efficiency directly due to condensing.

13 The installation of a low-pressure turbine may also be a doubtful expedient in a plant which is being electrified and in which the engine is belted or coupled to a lineshaft so that the direct load is decreasing while the electric load is increasing. Of course a generator could be added to the engine, and a low-pressure turbine run in connection with this; but beyond the combined capacity of these it would become absolutely necessary to install a new unit. Under such circumstances the best course would be the installation of a high-pressure condensing turbine to start with.

PROF. E. F. MILLER. I recently made some calculations upon the economy of the low-pressure turbine and found in figuring over some of the tests quoted an apparent efficiency of 76 to 80 per cent of that obtained from the non-conducting engine. I also worked up the efficiencies and steam consumption of the Rankine engine using

dry steam at a pressure of 15.6 lb. and exhausting at 28-in. vacuum. The same calculations were made at other pressures down to about 6 lb., as shown in Table 1. Taking the efficiency of the generator as 83 per cent and the mechanical efficiency of the engine as 90 per cent, the steam consumption per kw-hr. was obtained.

2 Assuming the ratio of efficiency of the low-pressure turbine to that of the non-conducting engine as 63, 67.5 and 72 per cent, the steam consumptions per kw-hr. were calculated. Table 1 affords a simple means by which steam consumptions may be compared.

TABLE 1 STEAM CONSUMPTIONS OF LOW-PRESSURE TURBINES AT VARYING PRESSURES

Abs. Press. at Entrance	Temp. at Entrance deg. fahr.	Abs. Press. at Exit	Temp. at Exit deg. fahr.	Quality of Steam at entrance	Quality of Steam at Exit	Thermal Eff. of Non-Cond. Eng. %
15.60	215	1.005	102	1.000	0.8785	15.93
14.13	210	1.005	102	1.000	0.8827	15.38
11.53	200	1.005	102	1.000	0.8916	14.23
9.34	190	1.005	102	1.000	0.9007	13.03
7.51	180	1.005	102	1.000	0.9125	11.75
5.99	170	1.005	102	1.000	0.9203	10.48

Abs. Press. at Entrance	Steam per h.p.-hr. of Non-Cond. Eng. per cent	Steam per kw-hr. of Non-Cond. Eng. Calling Mechanical Eff. of Eng. 90 per cent and Eff. of Generator 93 per cent	Steam Consumption per kw-hr. of Low-Press. Turbine Assuming Ratio of Act. Eff. to that of Non-Conducting Eng. as 63, 67.5 and 72 per cent		
15.60	14.72	23.55	33.6	31.4	29.4
14.13	15.23	24.36	34.8	32.5	30.4
11.53	16.50	26.40	37.7	35.2	33.0
9.34	18.09	28.94	40.1	38.6	36.2
7.51	20.13	32.20	46.0	42.9	40.3
5.99	32.66	36.26	51.8	48.3	45.3

EDWARD L. CLARK. A number of cases have arisen where mills driven mechanically have desired to increase their power by the use of low-pressure turbines. The introduction of the low-pressure turbine in such places is accomplished in a novel and effective manner by tying the electric load and the mechanical load together by means of a synchronous motor or generator. The synchronous motor may either be belted or coupled-direct to the main lineshaft driven by the engine, and then electrically interlocked with the generator connected with the low-pressure turbine. With this method, the low-pressure

turbine requires no governor and merely delivers power in proportion to the quantity of steam exhausted by the engine.

2 It is important in the selection of a low-pressure turbine that it should be capable of utilizing the entire engine exhaust. In this arrangement, the turbine may be regarded as the low-pressure cylinder of a triple-expansion engine, and manifestly a proper ratio between the low-pressure turbine and engine cylinders should be chosen. If this feature is not observed, the expansion of the steam will not be efficiently carried out or there will be free escape of a part of the steam through the relief valve between the engine and turbine. However, a properly selected turbine will pick up the electrical load and the surplus power that it is delivering will go through the synchronous motor, thereby lightening the load of the engine. When the engine is thus relieved of a portion of its load, it naturally gives less steam to the turbine until the whole system automatically balances between the mechanical load and the electric load.

3 An important feature of operating the low-pressure turbine without a governor is that vacuum comes back on the engine at all loads, the amount of this vacuum being proportional to the amount of load carried by the turbine. By thus varying the inlet pressures on the turbine and maintaining them below atmospheric pressure, looping of the low-pressure card on the engine at light loads is avoided and the low-pressure valves operate smoothly and without noise at all loads. At the same time, both the engine and turbine run in combination at maximum efficiency through their entire range, and the curves obtained are about as straight as the one in Mr. Stott's test.

4 It will be seen that the flexibility of such an outfit is independent of the mechanical load and the turbine can accomplish practically anything that a high-pressure turbine can accomplish. The gain in power with the synchronous motor system amounts to nearly 100 per cent, due to the fact that the increased rating of the non-condensing engine over what it is at best economy condensing is approximately 20 per cent, which should be added to the 80 per cent additional power given by the low-pressure turbine.

5 Assuming that an engine running under 125 to 130 lb. pressure consumes per indicated horsepower 15 lb. steam, condensing, and 21 lb. non-condensing, and if we divide the additional steam required when running non-condensing by the kilowatts obtained from a low-pressure turbine, we obtain a kilowatt for very close to 12 lb. additional steam per kw-hr. This must be compared with a water rate of say 20 lb. on a high-pressure turbine under the same steam conditions.

6 An interesting point is that the economies obtained for the combined engine and turbine would be equivalent to a consumption of about 11 to 11½ lb. per indicated horsepower in steam engine practice, so that we better the engine economy over what it is at its best point when run condensing, besides producing a kilowatt for less steam than in a high-pressure unit.

7 In the majority of cases the low-pressure turbines have been installed in plants having from 125 to 140 lb. of steam, and the relative gain is just as marked as in the stations carrying 195 lb. of steam and high degrees of superheat.

E. D. DREYFUS. It is interesting to note the remarkable difference in Rankine cycle efficiency between the engines and the low-pressure turbines. This looks as if there is some opportunity for improvement on the low-pressure turbine. Mr. W. B. Flanders of East Pittsburg, has made quite a study of turbine efficiencies, and has found that a high-pressure complete expansion turbine operating with 175-lb. steam pressure and 100-deg. superheat will give the same Rankine cycle efficiency as a low-pressure turbine at the same vacuum and using dry saturated steam.

2 The gain in economy of 13 per cent, as stated by Mr. Stott, is what would be expected when we consider that this unit is operating on dry and saturated steam. I must, therefore, differ with Mr. Rotter, as I know of no complete expansion economies on record that do not agree in the main with what Mr. Stott has brought out. A Rankine cycle efficiency of 70½ per cent on a complete expansion machine, but no turbine performance reaching this degree of efficiency has to my knowledge been recorded in this country. Some have gone as high as 67.8 per cent, but as far as I am able to learn, no record of a complete expansion machine has exceeded 70 per cent.

3 I am very much interested in observing the results obtained with constant and variable exhaust pressure. When this question first came up in low-pressure turbine work, variable exhaust pressure was looked upon with disfavor by some designers and engineers, while others advocated this method because of the better results obtained with it. It is now quite evident that in the neighborhood of 5 per cent additional economy is obtained by running with variable exhaust pressure. As Mr. Stott has stated, it is obvious that unless the piping and apparatus between the engine and turbine are in very good condition, good vacuum will not obtain. I find,

however, that there are a number of low-pressure turbine installations where the low-pressure turbine is coupled with two or more compound Corliss engines with moderately long connections, and they secure

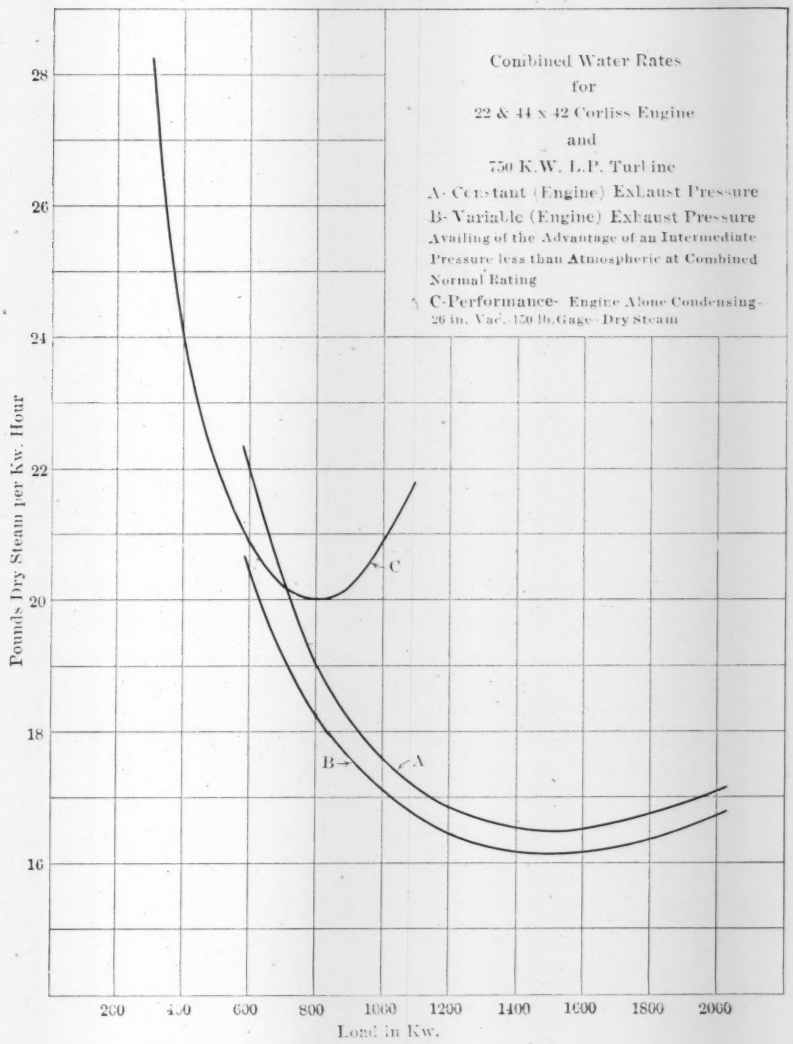

FIG. 1

a vacuum in the neighborhood of 28½ or 29 in. The overall economy, even in the small 1000-kw. units, indicates the same relative gain as

shown by Mr. Stott's results. Fig. 6 and Fig. 7 in Mr. Stott's paper, show the desirability of variable pressure operation on account of looping of the cards.

4 Mr. Stott mentioned in the first part of his paper that the maintenance account of a complete gas-engine plant would be from four to ten times that of a turbine station. To the best of our ability in collecting information and judging working conditions, we do not find it comes up to this factor, and the same thing is true in England according to a paper presented before the Institution of Electrical Engineers on November 17, 1908. This paper was very thoroughly discussed at London, Dublin and Manchester, both favorable and adverse comment being made, but the prevailing opinion seemed to be that the maintenance cost of the complete gas plant would not much exceed that of the steam turbine plant; in fact, the author of this paper claimed it to be the same. When the producer and boiler are considered, there is reason for this statement.

5 Regarding the statement that the results obtained closely approach gas-engine efficiencies, gas-engine coal consumption is usually given for 12,000 to 13,000-B.t.u. coal, but considering 14,500-B.t.u. coal in both steam and gas plants, a material difference of 20 to 25 per cent will easily be obtained in favor of the gas equipment over the most efficient steam machinery.

6 The value of the low-pressure turbine is rapidly bringing about its extensive use in connection with the gas engine, availing of the waste heat of the jacket and exhaust.

DR. CHARLES P. STEINMETZ. The paper deals with a combination of the low-pressure steam turbine with the induction generator, which, while possibly not familiar to some, is assuming a very high industrial importance.

2 The electrical part of the unit, the induction generator, is not a new type of machine. Its existence was known and its characteristics and behavior investigated and discussed many years ago; but only now has the industry developed in such a manner as to give conditions in which the induction generator is preferable to the synchronous generator.

3 There are two kinds of alternating-current generators: the synchronous generator, which is the ordinary alternating-current machine with which we are familiar, and the induction generator. Constructively, the stator or stationary structure of both types of alternator is practically the same in construction. It comprises a polyphase

winding, in which the electromotive force is induced by the rotating magnetic field, arranged in a laminated structure. The difference between the synchronous generator and the induction generator is in the rotor. In the synchronous generator this is a revolving magnetic field excited by direct current; while in the induction generator it contains a short-circuited winding the same as the armature winding of the familiar induction motor. From this variation results the difference in the production of the magnetic field which by its rotation induces electromotive force in the stationary generator winding. The magnetic field of the synchronous generator is produced by the action of the direct current in the field poles; that of the induction generator is produced by the reaction of the alternating currents issuing from the induction generator. As a consequence the synchronous generator must run in step with the frequency of the alternating system; that is, the rotor must move exactly one pole for every reversal of voltage in the external system. Conversely, the induction generator cannot run in step with the frequency but must always run faster, exceeding synchronism by an amount depending upon the load, so as to cause the induction in the short-circuited windings which produces the currents therein. That means that synchronizing is not required in the induction generator. Furthermore, since the induction generator does not depend upon running in step with any other machine, the possibilities of see-sawing, the so-called hunting which may occur in the synchronous machine, cannot exist with the induction generator.

4 The difference in the production of the magnetic field of the two types of alternating-current generator is the cause of the very characteristic variations in their performance. The magnetic field of the synchronous machine and, therefore, the electromotive force induced in its armature, depends on the direct current supplied to its field winding, but is essentially independent of the load of the machine. It is dependent only in so far as the current output and the power factor modify the field, varying it in the manner expressed by the term "regulation of the machine". The induction-motor field is produced by the reaction of the currents issuing from the machine. The induction generator, therefore, has no regulation and no magnetic field, independent of the voltage at the terminals and the load, but the magnetic field of the induction machine is produced by the reaction of the currents at a value corresponding to the voltage produced at the induction-generator terminals by the synchronous machines connected to the same system. The induction generator

depends in its magnetic field and voltage on the excitation of the synchronous machines in the same system; that is, it can generate only when connected to a system to which synchronous machines are also connected, whether synchronous generators, motors, converters or equivalent apparatus. It has no voltage of its own and cannot operate on a system on which no synchronous machine is connected.

5 The regulation of such a combined system of synchronous and induction machines, therefore, is by the regulation of the synchronous machines operating on the system. Any change of load varies the voltage as it would be varied if this change of load occurred on the synchronous machines in the system. The induction generator is merely a machine feeding electric power into the system but not participating in the voltage regulation or voltage control and having no direct effect on the voltage. While the synchronous machine at open circuit has a terminal voltage, the induction generator ceases to generate and has no voltage at its terminals at open circuit if it is disconnected from the alternating system. In a synchronous generator, even when short-circuited, the electromotive force continues to be induced in the armature windings because the magnetic field is still there as produced by the direct current. The synchronous generator therefore has a short-circuit current which may be many times full-load current, since the total induced electromotive force must be consumed inside of the synchronous generator armature. An induction generator, when short-circuited, has no voltage at the terminals, and therefore receives no current, has no magnetic field, and ceases to generate. In the induction generator when short-circuited, the current dies down from its previous normal value to zero at a rate depending on the resistance and inductance of the internal circuit in just the same manner as the current in a reactive coil, for instance, would die down when the coil is short-circuited and the impressed voltage withdrawn from it. The short-circuit current of the combined system of synchronous and induction generators is therefore only the short-circuit current of the synchronous generators.

6 There results therefrom also the characteristic difference that the synchronous generator can generate current of any character, energy, reactive or wattless lagging or leading, depending on the nature of the system to which it is connected, or the power factor of the supply system; while the induction generator can generate only energy current, and in addition continuously consumes or receives a certain amount of reactive or wattless lagging current re-

quired for its excitation. This latter it receives from the synchronous generators or the synchronous motors and converters in the system. The induction generator, therefore, cannot supply alone a general alternating-current system, for instance, a system of light and power distribution, which requires energy current, as well as reactive, or wattless lagging current; and where a combination of synchronous and induction generators is used, all the lagging current of the system must be supplied by the synchronous generators, and in addition the lagging current also consumed by the induction generator for its excitation.

7 In a system in which there is considerable lagging current, a very large percentage of induction generators is a questionable advantage, since it may throw an excessive overload in current on the synchronous generators, the latter having to supply all the lagging current. On a system requiring no lagging current, or being built to supply lagging current, as rotary converters or synchronous motors, which is the type of system on which Mr. Stott's generators operate and is usual in the large electric power generating and distributing systems, mainly of 25-cycles, there is no lagging current required because the system can be run at unity power factor or even at leading current, and the synchronous motors and converters can be caused to supply the lagging exciting current of the induction generators. There the induction generator is at its greatest advantage.

8 The difference may possibly be described by saying the synchronous generator generates electric current while the induction generates electric power. That is, the synchronous generator supplies electric current to the system whether this current is a power current or a wattless, powerless current; the induction generator can supply only power current and no wattless current. The induction generator, therefore, is the typical converter from mechanical into electric power. It consumes mechanical power and supplies electric power without depending for its supply on field excitation, speed, synchronism or any other feature. It is consequently the ideal machine to float on an alternating-current system, by receiving whatever mechanical power is available and supplied to it in a low-pressure steam turbine from the exhaust steam of reciprocating engines; or in the hydraulic turbine from whatever water power there may be available. It receives the mechanical power and converts it into a proportional amount of electric power, at whatever voltage the system happens to run on, and at any speed, speeding up just above that for which the system is set by its frequency, but with no necessary regulation.

Its straight and simple function is the conversion of one kind of energy to the other, separate entirely from the problem of regulation and adjustment which is thrown over into the synchronous machines in the same system. This is what makes the induction generator a simple and convenient apparatus for cases like that described in the paper and for all others where mechanical power is to be picked up from water powers here and there, and is too small, possibly, to warrant installation of specific regulating mechanism.

DR. CHAS. P. STEINMETZ. There is an interesting and somewhat unexpected result shown by the tests, namely that the efficiency was found higher when operating the turbine with varying nozzle pressure than when operating with constant nozzle pressure. The explanation of this is given by the curves in Fig. 13 and Fig. 14. In the latter the efficiency of the low-pressure turbine is higher for constant nozzle pressure, just as expected, but constant nozzle pressure of the turbine means constant exhaust pressure of the steam engine and with this and the varying load, as shown in Fig. 13, the efficiency of the steam engine falls off, dropping from the maximum point at a rate which is so much greater than the gain in efficiency of the steam turbine that the combined efficiency shows an advantage in favor of varying nozzle pressure. This illustrates the fact that the turbine side is much less sensitive to variations of the operating conditions from its best condition than the steam engine is, and that to get maximum economy in the operating conditions the engine should be favored. But that also throws a side-light on one of the reasons why the Rankine efficiency of the turbine is less than that of the steam engine part, because all the unfavorable conditions of operation must be thrown on the turbine side of the cycle to get maximum average resultant efficiency.

2 The gain in efficiency due to the addition of the low-pressure turbine is on the lower side of the cycle, because of the ability of the turbine to expand the steam to a pressure lower than the exhaust pressure of the low-pressure cylinder of the steam engine, an extension impossible with the reciprocating engine. The combined apparatus gains in the ability of the turbine to do what the reciprocating engine is not able to do. This must be kept in mind when comparing the low-pressure turbine and steam-engine plant with the high-pressure turbine plant.

3 The reciprocating engine in general cannot gain by superheat as much as the steam turbine gains, and comparison of the combined efficiency of a saturated-steam reciprocating engine and low-pressure

turbine, with a high-pressure turbine is not quite fair to the latter, because on the high-pressure side. The steam turbine can get an additional gain in efficiency by using superheat which the reciprocating engine cannot to the same extent. In comparing things it is always difficult to get conditions which are equally fair to both types of apparatus because the conditions of proper operation are different in each.

J. W. LIEB, JR. The author is somewhat optimistic in his estimate that it would be possible to realize as much as 20 per cent of the installation cost from the sale of used apparatus. It would probably be necessary to accept a lower figure, but the result, however, would be still more in favor of the installation of the low-pressure turbines.

2 In the application of the induction generator we have a solution of the problem which combines simplicity of construction and operation with a minimum of installation cost. The induction generator is also of notable assistance in solving the otherwise very difficult problem of handling through the available types of switching gear the enormous energy which might with the usual types of apparatus be difficult to handle in case of a short circuit on the bus bars.

3 The results of the condenser tests are particularly interesting on account of the high rates of heat transference, considerably in advance of the results hitherto attained.

4 The paper is a notable contribution to the economics of power plant engineering and the apparatus described should serve to give a new lease of life to otherwise antiquated engine-driven equipments, although it would be difficult to find another case where the application could be made with such manifest advantages.

DR. D. S. JACOBUS. I visited the plant of the Interborough Company while Mr. Stott's tests were being made and desire to commend most highly the degree of accuracy observed and the general character of the work.

2 The economy of all piston steam-engine installations may not be improved as much as 25 per cent by adding a low-pressure turbine. By examining the paper on tests made at the plant of the Pacific Light and Power Company at Redondo, California, presented to this Society by Mr. Weymouth, it will be found that the heat consumption with a steady load with piston steam engines was about 24,800 B.t.u. per kw-hr. The heat consumption was obtained by dividing

the heat of combustion of the oil burned at the boilers by the net electrical output in kilowatt-hours at the switchboard. The efficiency in the tests of the combined unit by Mr. Stott is 20.6 per cent based on the heat in the steam consumed, and if we take the efficiency of the boilers at 76 per cent, a figure obtainable with oil, the heat of combustion of the fuel burned at the boilers would be 21,800 B.t.u. The difference between Mr. Stott's figures and those obtained at the Redondo plant is, therefore, about 12 per cent. There is a further allowance for the fact that the steam was superheated about 100 deg. fahr. in the Redondo tests and this would increase the figure and make it come more than 12 per cent. It does not seem possible that the introduction of a low-pressure steam turbine at the Redondo plant could ever reduce the heat consumption 25 per cent, bringing it down to 18,600 B.t.u. per kw–hr.

3 The results obtained by Mr. Stott are very close to those which can be secured with large gas engines. The economy of 21,800 B.t.u. could be reduced with proper superheat to about 20,000 B.t.u. per kw–hr., which would be all that could be expected of a producer-gas plant if run on a commercial swinging load with high daily peaks and periods of low power. In a 15 days' continuous test made at the Redondo plant where the load varied daily through a wide range from high peaks to periods where but little load was on the station and where there was a lay-over period of $4\frac{1}{2}$ hours per day, the heat consumption averaged about 25,000 B.t.u. per kw–hr. and it is questionable whether a producer-gas-engine installation could do very much better with a load of this character.

MR. SCHAUBER. In regard to the statement that the result obtained with the engine-turbine-unit had closely approached the best efficiency obtained in gas-engine practice, I desire to call attention to the installation of four 2000-kw. units at the Illinois Steel Company, operating on blast furnace gas. Records kept for six months under working conditions show a consumption of 15,000 B.t.u. per kw-hr. at the switchboard. When this result is compared with the 21,000 B.t.u. per kw-hr. at the 59th Street station, the comparison is more in favor of the gas engine than the statement made in Mr. Stott's paper.

DR. D. S. JACOBUS. The 15,000 B.t.u. quoted by Mr. Schauber is based on the heat of combustion of the blast furnace gas used by the engines. If there had been a producer this value would correspond

to that computed on the basis of the low heat value of the gas, and where allowance is made for losses through all auxiliaries, this figure would have to be divided by about 0.7 to give the heat units in the original fuel. This would give a much higher heat comsumption, say, over 20,000 B.t.u. per kw-hr.

G. R. PARKER.[1] The question often arises as to the smallest size of plant in which a low-pressure turbine can profitably be made, and while no accurate data are yet available, I consider it doubtful if very satisfactory results can be obtained in plants of less than 300 or 400 kw. This is due to the fact that the actual cost of producing power in small installations is not made up so largely of coal as it is in large installations, the labor and the numerous operating expenses constituting a much larger percentage of the cost.

2 A word of appreciation is due Mr. Emmett for the persistance with which he has worked on the problems of the turbine industry, through many early trials and difficulties, until his latest and possibly his greatest achievement, which Mr. Stott has so ably presented. I feel confident that engineering posterity will give due credit to Mr. Emmett.

O. JUNGGREN. The over-all efficiency shown by Test 51, Table 8, is 72½ per cent of the total available energy between the steam entering the engine and the recorded exhaust pressure of the turbine. Test 42 shows an efficiency of 69.6 per cent, and another, 68.7 per cent under different conditions of load and vacuum. A high-pressure turbine, working under the same conditions of steam pressure and vacuum, would probably not give as high an efficiency over such an available range of load as that given by the combined unit, but a high-pressure turbine of approximately the same size could reasonably be expected to give 70 to 70½ per cent at the the most economical load, although fractional efficiencies would not be as good as for the combined unit. A high-pressure turbine would be considerably cheaper then the combined unit and in the near future high-pressure turbines will be made having as high an efficiency as the combined unit, and still be cheaper than a combination of engine and turbine. The vacuums obtained in these tests are quite remarkable and show what can be done in actual practice.

[1] General Electric Co., Schenectady, N. Y.

F. SAMUELSON[1] said that the field for variable-pressure turbine work, not yet developed in America, has been fully opened up in England and the business is in a very healthful condition. Low-pressure turbines of various types have been employed and all are proving fairly successful. The chief difficulty in the installation of these machines has been to meet the Board of Trade regulations as to constant back pressure on hoisting engines. Accidents are sometimes caused by a drop in back pressure at the engine, due to demands upon the accumulator by the turbine. To prevent this trouble a simple automatic valve has been employed between the engine and the accumulator to shut off the supply from the engine when the accumulator pressure falls to atmospheric. While the regulating valve is closed the turbine is supplied with steam at a reduced pressure. This valve works equally well between the turbine and the accumulator, but the capacity of the latter is much reduced because of the small pressure limit between which it operates. This results in the use of high-pressure steam in the turbine on short stoppage of the engine.

THE AUTHOR. Refiguring one of the assumed cards (Card C, Table 3, series B) for 100 deg. superheat, we get an actual water rate of 12.9 lb. per h.p. instead of 13.6 with saturated steam, since the missing water and leakage is cut to less than 0.1 of the original value in the high-pressure cylinder. As the missing water in the high-pressure cylinder forms about 0.6 of the total missing water, we shall have 0.46 of the original missing water in this case, or $0.156 \times 0.46 = 0.072$, say roughly 0.08. The B.t.u. supplied per hour $= 12.9 \times 9836 \times 1259 = 159{,}800{,}000$. Radiation and conduction, 1 per cent = 1,598,000 Bt.u.-hr. High-pressure cylinder work $= 5080 \times 2545 = 12{,}940{,}000$ B.t.u-hr.; this leaves 145,262,000 B.t.u. in the steam at high-pressure exhaust, or $\frac{145{,}262{,}000}{126{,}900} = 1145$ B.t.u. per lb. At 52.2 lb. absolute, this corresponds to a quality of 96.8 per cent or 3.2 per cent moisture; of this about 2 per cent will be thrown down as receiver drain.

2 The heat thus removed is $0.02 \times 126{,}900 \times 253 = 643{,}000$ B.t.u., leaving 144,619,000 B.t.u. in 124,360 lb. of steam, delivered to the low-pressure cylinder. Low-pressure radiation, $0.01 \times 144{,}619{,}000 = 1{,}446{,}000$; low-pressure work $= 4756 \times 2545 = 12{,}100$,

[1] Turbine Engineer, British Thompson-Houston Co., Rugby, England.

000; leaving 131,073,000 B.t.u–hr., or 1065 B.t.u-lb. which at 13.5-lb. absolute exhaust pressure gives a quality of 91.5 per cent, or 113,800 lb. dry steam available for the turbine. This will give 3,700 kw. on the turbine, which added to the 6710 kw. on the engine gives 10,410 kw. at 12.18 lb. per kw-hr. as against 14.2 lb. with saturated steam. In actual practice the 14.2 rate was cut down to 13.25, and it is reasonable to expect the same sort of result under superheat.

3 The reciprocating engine, when designed for superheat, makes just as good use of it thermodynamically as a steam turbine, but will not stand so much superheat. The point has been raised, that a moisture correction on the turbine is not fair, since without reheating it is not possible to reduce the moisture in the turbine steam to zero. It is fair in this sense, that in order to compare the various water rates on the same basis, it is necessary to reduce all steam conditions to a standard and that standard is naturally dry steam. Moreover, when the moisture gets as low as 1 per cent or 2 per cent the correction is negligible in amount, and the curve of corrected water rate is substantially true. It is quite possible that a separator can be designed that will take out all but 0.2 or 0.3 per cent of moisture; and in this case the correction justifies itself.

TOPICAL DISCUSSION ON THE RELATION OF THE STEAM TURBINE TO MODERN CENTRAL STATION PRACTICE

By G. R. Parker[1], Schenectady, N. Y.

Non-Member

In regard to turbine installations the question is often asked as to what are the most economical steam conditions, i.e., initial pressure, vacuum and superheat. While there is much discussion on these points, the present American practice is becoming reasonably standardized. As to vacuum, there is no question that it is worth while getting the highest obtainable, provided an ample supply of condensing water is available. Twenty-eight inches or even higher vacuum can readily be obtained with modern condensing apparatus. Steam pressures vary from 150 lb. gage to 250 lb. gage. In the smaller and medium sized plants probably 150 to 175 lb. is about right, while in the larger ones 175 lb. to 250 lb. should be

[1] General Elec. Co., Schenectady, N. Y. Discussion given at St. Louis December 11, 1909.

employed. The arguments for and against superheat are numerous, but the consensus of opinion is inclined to favor it to a reasonable degree, at least in the large and medium sized plants. Superheat ranging from 50 deg. fahr. to 250 deg. fahr. is in common use.

2 Modern steam-turbine practice has advanced so rapidly in the past few years that quite startling changes have been effected in some of the original turbine stations. Improvements in details of construction and increase in speed have greatly reduced the size and weight per kilowatt. About six years ago the first large turbines were installed in the new Fisk Street station of the Chicago Edison Company. The first three machines were vertical 2-stage machines of 5000-kw. capacity, and the fourth, installed somewhat later, was of the same capacity but of the 5-stage type. Within the last year these four machines have been removed and replaced by four vertical machines of 12,000-kw. continuous capacity each. These occupy no greater space than the original machines, and no increase in the number of boilers supplying them was necessary. The Fisk Street station now contains ten similar machines of 12,000-kw. each. The Quarry Street station of this same company at present contains three vertical machines of 14,000 kw. each and three more will be installed during the coming summer. The economies obtained in these plants are reflected in the rates the Commonwealth Edison Company is able to make its consumers.

3 A somewhat similar evolution is now under way in St. Louis. In 1905 the Union Electric Light and Power Company installed two 5000-kw., 500-r.p.m., 25-cycle, 6600-volt, vertical turbines. Later two more 5000-kw. machines were added, but with 60-cycle, $\frac{2300}{4000}$-volt generators. The present plan, which is now well under way, is to replace all four machines with other turbines of 12,000-kw. capacity each.

4 The natural question is, can it possibly be a good business proposition to throw out four large turbines which have been in use only three or four years? That the answer was affirmative was due to three principal considerations.

a The larger machines could be installed without increase in floor space.

b The improvement in economy represented an annual charge which if capitalized would more than pay for the additional investment.

c Practically no new auxiliary apparatus or station piping would be required.

That these considerations were based on correct assumptions has been amply demonstrated. The first 12,000-kw. turbine has now been in commercial operation for several weeks.

5 In making this installation not only was it found possible to utilize the original foundations, but even the base of the old turbine, which also constitutes the exhaust chamber and step bearing support, was utilized in building the larger machine. It was, therefore, not necessary to remove this base from the concrete, or to break the connection to the condenser. The increase in capacity means that in this portion of the station the kilowatts per square foot of station has been more than doubled. Even the original four 5000-kw. machines were placed unusually close together and when the remaining three are replaced by larger machines it seems probable that the turbine portion of the station will show a greater output per square foot than any other station in this country.

6 On the question of economy, it would seem that we are approaching very close to the limit with the latest turbines. There are certain losses inherent in the turbine, such as those due to radiation, to wheels revolving in atmospheres of different densities, and the friction of the steam on the blades, which make it doubtful if we shall ever succeed in getting an efficiency of more than 75 per cent. Rapid progress toward this mark has been made in the last few years, largely due to better bucket design, until the latest machines in the Union Electric Light and Power Company's plant have a theoretical economy of 66 per cent.

BALL-BEARING LINESHAFT HANGERS

By Henry Hess, Published in The Journal for May 1910

ABSTRACT OF PAPER

The paper gives in detail the actual and relative first cost of a lineshaft installation, consisting of hangers, boxes, shaft, pulleys and belt, transmitting 40 h.p. at 200 r.p.m., on plain bearings, then on ball bearings, at 600 r.p.m. The latter installation costs less by $117.08, a saving of 21 per cent in first cost; this carries with it an annually recurrent saving of $36.90 in power.

The hanger and ball bearing are described and illustrated..

DISCUSSION

Frank B. Gilbreth. Is there any information available regarding a comparison of the manner in which concrete buildings and so-called mill buildings affect ball bearings? Nearly all engineers practicing in the construction of concrete buildings believe that the lack of vibration in this type of building lowers the cost of maintenance of lineshafting, hangers, bearings, and similar machinery.

Charles Whiting Baker. One argument against concrete buildings is that the dust raised is injurious to the working parts of machinery. It would be interesting to know whether ball bearings will stand that dust better than plain bearings.

2 Where it is desired to dispense with lubricants, at least so that there shall be no dripping, does the ball-bearing lineshaft solve the difficulty?

Frank B. Gilbreth. If the point about dust in concrete buildings is to be raised, they should be separated into two classes, those with wooden floors and those with concrete floors. There cannot be any dust in a concrete building with a wooden floor.

2 I would like to know what method is best in a concrete building for holding a lineshaft hanger to the ceiling; not only a ceiling with

ribs, but also of the flat type. Hangers are usually of two types, those that can be located before the building is erected and those put in afterward. Concrete men have studied that subject a great deal but do not feel that they know the needs of the hanger men or of the bearing men.

F. W. DEAN. It is quite evident that wooden mill buildings must have the shafting lined up frequently to get minimum friction, but a concrete building is supposed to preserve its alignment after it is finished and set. There is great opportunity for the diminution of friction in mills. It is not always a question of bearings, but sometimes of the arrangement of driving machinery. In a mill where the friction load was 42 per cent of the running load, an examination showed that it was due to a great number of quarter-turn belts.

J. SELLERS BANCROFT. I wish to correct an error in Mr. Hess' paper where he ascribes the invention of the ball-and-socket hanger to Mr. Bancroft, one of the oldest members of the Society. The invention was made about 1848 by my father, Edward Bancroft, who died many years before the society was organized.

G. N. VAN DERHOEF. In Par. 4 of this paper, Mr. Hess referred to the early type of hanger with ball-and-socket plunger screws and mentioned the stress of modern conditions as leading up to modern hangers with very little machine work. These conditions may have had some bearing, but experience has shown that extensive machine work is not necessary. Carefully fitted machine parts at the end of the plunger screw are unnecessary because the vibration of the shafting will level the bearing. After the box is in its proper position, it will stay there until the settlement of the building requires realigning of the shaft. With the ordinary hanger box, the pressure required at the end to bring it into position is very slight. Accurate machine seats, however, are proper and an absolute necessity in the case of ball bearings, where a single row of balls is used, because there is no leverage, the balls being in direct line with the plungers. The friction must be reduced to almost nothing or the bearing will tend to cramp on the shaft.

2 In his list of desirable features for hangers, Mr. Hess mentions horizontal adjustability of the box within the hanger body. This is rather a mooted question on which are two widely different beliefs.

One is that the box itself should move across the hanger or frame and the other is that the hanger body itself should be used as the movable body. Anyone who designs a four-point hanger will soon find difficulties in moving the box across the frame without introducing complications.

3 In regard to neatness of general outline and conformity to modern machine design by substituting box sections for ribbing, neatness is desirable, but the substitution of box sections for ribbing is unimportant. The amount of metal necessary in any cast-iron hanger frame to take care of vibration enables almost any shape to be used which will have the requisite strength. It is rare for any cast-iron hanger to break under load.

4 Fig. 1 shows the box itself carried by screws at the side, a construction similar to that in what is commonly known as the Boston hanger, which has been used for a great many years in the eastern part of this country. The defect of this type is that it carries the weight of the box directly upon the side screws and its swiveling in that way is hard on such small bearings. To get horizontal adjustment the box must be shifted out of the center line of the vertical plunger screws, which is bad practice; or the vertical plunger screws must be shifted at the same time as the box. If the vertical plunger screws are left in a fixed position the center of the box is shifted out of its correct location in line with the axis of the main screws. If the screws are shifted they must all be loosened and tightened up again every time the box is shifted sideways, Even then it is likely to be out of line vertically. Mr. Hess has approximated the solution of the problem by using a great deal of machine work and it is really necessary if these complicated adjustments are wanted. This type of hanger frame is needlessly expensive for ordinary conditions.

5 Mr. Hess mentions the advantage of running a shaft at high speed, say 600 r.p.m., and makes the statement that a shaft with ball bearings can be run at a higher speed than a shaft with plain bearings, but not long ago I saw a number of shafts 80 to 100 ft. long and about $2-\frac{1}{16}$ in. in diameter, with plain bearings, running successfully at 700 r.p.m. The shafting and hangers were ordinary materials bought out of stock, without the seller knowing anything about the speed at which they were to run.

HARRINGTON EMERSON. For miscellaneous and scattered shops the power plant which is dependent on coal, cheapest to install and maintain, as well as cheapest and most reliable to operate, consists of:

a A gas-producer plant near a side track.
b Gas transmission by mains.
c Individual gas engines on main lineshafts running 400 to 600 r.p.m.
d Leather belt transmission to jackshafts and machines.

2 I therefore welcome ball bearings on lineshafts as an important aid to this form of power transmission. I much prefer the installation outlined to turbo-electrical generation, wire transmission and motor drives.

THE AUTHOR. If the dust from a concrete building is allowed to get into ball bearings they will be destroyed just as any other bearing would be under these conditions. The problem is to keep the dust out, and in the case of ball bearings it is an exceedingly simple matter to keep foreign matter out and the lubrication in under the most adverse conditions. This is done by extending the bearing box on each side enough to allow for two additional grooves in addition to the one usually employed. The two outer grooves prevent the dust from getting to the bearing and the third or inner groove traps the oil or other lubricant and drains it back to the bearing. Even in a marble plant, where the dust is considerable in amount and a more efficient cutting material than emery, no trouble has been experienced with ball bearings and the lubricant is renewed but once each year. The same device has been successfully employed in submarine dredges under a 40-ft. head of water to keep the water out of the bearing and to prevent loss of the lubricant.

2 The Thompson Meter Company in Brooklyn occupies a concrete building and is equipped throughout with ball bearings with no trouble from the concrete dust. Even in mills where there is a considerable quantity of lint floating in the atmosphere it never gets into the bearings.

3 Ball bearings were first applied to steam railroad passenger cars in Europe and the first cars have now run over 600,000 miles. They were originally charged with pale yellow vaseline and after they had run 140,000 miles I found it still pale yellow in color. This indicates that there has been no deterioration in the lubricant and that the closure of the bearings was effective.

4 Regarding Mr. Jackson's question as to the advantages of ball bearings at high speed, it is manifest that the plain bearing with heavy load is much more difficult to lubricate and must be more carefully looked after to insure sufficient lubrication than is neces-

sary with the ball bearing. There is a general impression that the ball bearing may be run without any lubrication whatever, but this is not true. If they could be made of absolutely incompressible material and absolutely true balls and races could be produced they would probably need no lubrication. Furthermore, with high-speed lineshafting using either plain or ball bearings, smaller pulleys can be employed, requiring a smaller drop in the hangers. The loads on the bearings are therefore lighter and the belts are narrower and less expensive.

5 The ball bearing which is loaded to three or four times its rated capacity will show a slight heating, hardly noticeable to the touch. The amount of excess pressure put upon such a bearing by a large shaft that has gotten out of alignment is too small to show itself by heating. In fact, one of the troubles with users of ball bearings, particularly where thrust bearings are used, is the failure to realize that the friction is so little that even when the bearing is greatly overloaded that fact does not manifest itself in greatly increased resistance, as is the case with plain bearings. A bearing which is so overloaded that it shows additional resistance to turning or an appreciable rise in temperature is so seriously overloaded that it will soon be destroyed.

6 The question as to the relative frequency of alignment in mill buildings and the more rigid concrete buildings carries its own answer; the more rigid a building the less frequent will it be necessary to realign. When the building moves, the bearings have to be realigned. The difference between plain and ball bearings is that the former, in case of a considerable shift, will squeal and require attention, while the latter remains quiet, does not heat and its life is not even affected, because it has a sufficient margin to take care of such overloads. Nevertheless, such shifting should not be neglected because the work done in bending the lineshaft has to be paid for as power consumed. The proper thing to do is to put bearings in a hanger in which they cannot shift and thereby realize the benefits of rigid hangers and bearings.

7 The mill mentioned by Mr. Dean as having a 40 per cent friction load was probably a textile mill. In such mills the power is so large an element of the total cost that it is usually looked after very carefully. The shafting is generally well aligned, the hangers, bearings, etc., all receive close attention and frequent oiling, and consequently the best results as to low friction losses. In most industries a totally different state of affairs prevails. In machine

shops, for instance, the friction load of lineshafting and countershafting almost always exceeds fifty per cent, and in many cases it is as high as sixty-five and seventy per cent. In the Utica plant referred to, the substitution of ball bearings for plain bearings would have reduced the friction losses 60 to 90 per cent.

8 It has been stated that lineshafts with plain bearings were running satisfactorily at 700 r.p.m. There is no reason why such shafts cannot be run at 1700 r.p.m. except for the necessity of far greater care in maintenance and the relative friction loss. The ball-bearing lineshaft can be run at 600 r.p.m. without attention from one year's end to another; it is not even unnecessary to realize it, except for the power loss in bending the shaft. The limit of speed is not set for the ball-bearing lineshaft by the bearing, but by the requirements of the machine to be driven. In many cases they run at 17,000 r.p.m., but 600 r.p.m. is about the highest practicable for the average machine shop countershafts, where the pulleys must not be too small to secure sufficient belt contact.

9 The point was raised against the type of hanger described in the paper that when the box is shifted from the center of the hanger in the realigning, the shaft is out of line with a vertical drawn through its two supports. If the belts from the lineshaft were running vertically downward, the argument would be a valid one, and in such a case it would be desirable tohave the bearing centered in its support and coincident with the line of belt pull. Ninety-nine per cent of the belts, however, are run much more nearly horizontal than in any other direction. Those that do not run absolutely horizontal runs at some angle, usually but slightly deviating. This puts the pull in line with the horizontal support of the box and normal to the vertical supports. Therefore a cross-aligning movement of the box is of no moment. The principal requirement is that the hanger be sufficiently stiff. In the one described in the paper the yoke is of cast iron and the two vertical members cast with it have a considerable diameter and therefore sufficient stiffness.

AN IMPROVED ABSORPTION DYNAMOMETER

By Prof. C. M. Garland, Published in The Journal for March 1910

ABSTRACT OF PAPER

This paper describes a type of eddy-current dynamometer adapted for the absorption of power given out by motors under test, with an enumeration of the conditions that an absorption dynamometer should fulfil, illustrating the advantage of this machine.

The dynamometer consists of a copper disc revolving between the poles of an electro-magnet. The power absorbed is utilized in the generation of eddy currents in the disc, which short-circuit among themselves and produce heat, which is carried off by circulating water. The change in load is effected by a rheostat in series with the exciting coil. Attention is drawn to the flexibility of the design and the adaptability of the machine to both large and small powers.

DISCUSSION

C. M. Allen. This paper describes a unique and interesting form of absorption dynamometer, but practically all of the claims brought out in the paper are applicable to and descriptive of the Alden absorption dynamometer. The Alden absorption dynamometer never binds or seizes if it is properly set and operated, and with the automatic valve attached, the internal friction, temperature, wear, etc., have no effect on its keeping balanced steadily, holding the load constant for an indefinite period of time. It accurately indicates the load from full capacity practically to zero, merely the friction of its bearings is indicated, and I do not see why the dynamometer described in this paper would not have the same amount of initial load. The regulation of the load on the Alden brake is positive, and although not instantaneous in its true sense, the full load can be put on or off as quickly as the valve can be opened or closed. The Alden brake also requires very little attention if properly set up and operated. The automatic valve entirely does away with any hand manipulation, keeping the load constant for hours without any attention. For a given amount of horse power, the Alden brake probably takes up as little room as the one described in this paper, because the brakes can

be made with multiple discs. They run as quietly as any ordinary oil bearing and are as free from splash of oil and water. They are also readily changed from one prime mover to another. They can either be mounted on a portable stand, as the one described in this paper, or they can be put on the overhanging end of the engine shaft. The amount of cooling water ordinarily used would be a little greater with the Alden brake than in the electrical dynamometer described in order to keep the temperature of the machine lower for the best operation; but for small machines running at high speeds, it is perfectly feasible to run the cooling water hot enough to make steam.

2 We have used Alden dynamometers in the laboratory of the Worcester Polytechnic Institute for a good many years, ranging in size from discs 6 in. in diameter up to 34 in., in horse power from $\frac{1}{100}$ up to 150, and in speed from 0 up to 3000 r.p.m., and we are convinced that they are reliable, accurate and comfortable machines to work with. These brakes have always done the work demanded so exceptionally well that the writer has taken up the testing of large water-wheel units after installation. Further particulars concerning the action of these large dynamometers are given in the paper on The Testing of Water Wheels after Installation, published in The Journal for April.

3 The Alden dynamometers are used extensively in a large number of engineering schools of this country and abroad. They are also used by a great many of the largest automobile manufacturers in this country for testing their engines before installation in the cars, and in some cases after installation by connecting a dynamometer to each end of the rear axle.

4 These remarks concerning the Alden dynamometer are entirely unnecessary for those who are familiar with it, but were written for the benefit of those who are still looking for a reliable and accurate prony brake.

THE AUTHOR. I am very glad that Professor Allen has brought out the advantages of the Alden brake as compared with those claimed for the dynamometer described in my paper. The Alden dynamometer fulfils very nearly the specifications outlined for the magnetic dynamometer. However, I believe that the latter has the advantage of requiring less attention and about one-tenth of the weight of water, or in some cases much less; also of the elimination of mechanical friction which renders seizure of the rotating with the stationary parts a very remote possibility. While this is well taken care of in the Alden

brake, yet if the temperature of the water rises so that the lubricating oil becomes less viscous between the discs there is always present this danger. I further believe that the regulation or the changing of the load requires a greater amount of attention. The magnetic dynamometer, if properly constructed, operates as steadily as an electric motor and is, without doubt, the ideal machine in so far as operation is concerned.

THE ELASTIC LIMIT OF MANGANESE AND OTHER BRONZES

By J. A. Capp, Published in The Journal for March 1910

ABSTRACT OF PAPER

At a stress but little above the elastic limit, or the limit of proportionality of stress to strain, mild and medium steels show a characteristically sudden breakdown, such that during an appreciable interval the specimen stretches without increase of load. This point, called the "yield point", is marked by a jog in the autographic elastic curve, and is indicated by the dropping of the beam of the testing machine and the slipping of the points of dividers held in bench marks on the specimen. The paper deals with the elastic curves of brasses and bronzes, which show no such break or jog, but characteristically are smooth curves, substantially straight at first and gradually bending over at an increasing rate as stress increases. Hence the locating of a so-called yield point, in testing bronzes or brasses by commercial methods, is entirely a matter of the judgment of the operator, and the point reported bears no definite relation to the elastic limit or limit of proportionality as indicated by the elastic curve.

DISCUSSION

S. A. Moss. The point has been raised as to whether we are able to find the limit of proportionality in bronzes by the old steel method and I would like to raise the additional point, as to whether we are interested in the limit of proportionality at all. The engineer is interested in the permanent set, which may not be connected with the limit of proportionality in any way. It would be a good thing if we confined our attention to this set, and in making tests on materials almost wholly remove the load after each application, measure the permanent set, apply a greater load, remove it almost wholly, and again measure the permanent set. In this way we could make a curve of permanent set, and need not consider the stress-strain curve. Such curves are of the shape of the usual stress-strain curve, with quite a bend. The place where the bend begins should be defined as the beginning of the elastic limit, which is of much more interest to the engineer than the limit of proportionality or the yield point with which he is usually concerned.

2 This cold-drawing process, or application of stress for a second

time, is somewhat complicated. After material has once received a permanent set, it will not receive as great a one the second time. This must be taken into account and the place found where the appreciable permanent set begins after the second application of load. That necessitates applying and removing each load twice before measuring the permanent set.

F. W. DEAN asked if there was any evidence to show that a piece of steel left to itself for a time regained any of its original qualities.

THE AUTHOR. Mr. Howard at the Watertown Arsenal, has recently repeated tests on bars which were overstrained a great many years ago, and have since been laid aside to rest. The tests are not entirely completed, but there seems to be evidence that if the overstress is not so great that the particles have been definitely torn apart and set up in new arrangement, there will be almost an entirely complete recovery, in which the chances are that the original limit of proportionality will have been raised to a point between the original value and that of the overstrain.

2 Dr. Moss's statement with respect to the location of what we might call the first permanent set point is pertinent. It is perhaps a happy coincidence that in most of the materials commonly tested for engineering purposes, the first permanent set point and the limit of proportionality very nearly coincide. Taking into account the very long time it takes to conduct a test to determine the first permanent set point and the difficulties in making sure that the lower load selected as the zero point is always exactly secured, there is a justification for abandoning that method of test in favor of plotting the elastic curve, and getting the limit of proportionality. The points are not so far apart that the engineer is not warranted in basing the safe load on the limit of proportionality instead of on the first permanent set point.

3 Dr. Moss had mentioned as possible a material which does not show any permanent set until the stresses have been carried well out on the curved portion of the elastic curve. Cast iron is apt to be such a material. There is practically no straight line portion on the elastic curve for cast iron, and yet it is difficult to measure any permanent set when testing, even the ultimate elongations being small and difficult to measure. Several persons have reported as much as one-quarter per cent of elongation in eight inches, which is, of course, very little. The relatively more brittle metals usually test as high as four or five per cent, and tougher metals as high as forty per cent.

4 A jog in the stress-strain curve is characteristic of all the mild or untreated steels, and it is also true that overstressing eliminates it. That is shown in testing cold-rolled steel or steel wire, the extreme case of cold-drawn steel. Steel wire is obtained by a controlled stressing of the material beyond its elastic limit by drawing it through a die, which to a certain extent controls the amount of the permanent set and of the overstressing.

5 The real object of testing is to determine the characteristics of a material so that one may decide what shall be safe stresses in any structure, taking into account the elastic properties of the material, its ability to stand up under repeated or alternating stresses and other similar conditions. Usually such safe loads are a certain proportion of the elastic limit. If, however, the elastic limit is determined by erroneous tests to be double its true value, any calculation based on such data is utterly unsafe.

THE TESTING OF WATER WHEELS AFTER INSTALLATION

By Prof. C. M. Allen, Published in The Journal for April 1910

ABSTRACT OF PAPER

Brake tests of water wheels after installation have been in growing demand for the past few years. This paper describes the brake and its use in connection with the testing of large water wheels, with a few suggestions as to why a brake test is advisable after installation. Several tests are given showing the results in the form of curves of poor, good and exceptionally good water-wheel settings, with sketches of layouts. The efficiencies of large bevel gears, such as are used in large vertical drives, were determined by a brake test on both the horizontal jack shaft and the vertical wheel shaft, making a sufficient number of tests to insure reliability. The proper setting of a water turbine is described in a general way.

DISCUSSION

R. A. Hale.[1] The Holyoke testing flume has furnished much valuable information in regard to the efficiency of wheels, but it has always been apparent that differences in efficiency occur, depending on the conditions of installation. No absolute knowledge can be obtained without an actual test of the wheels in position to drive the mill. The example cited by Professor Allen of a pair of wheels placed so close together that the discharges interfere is common where space is limited and the quarter turns are crowded together at the expense of efficiency. Other undesirable conditions may exist, such as high velocity in the penstock and a small wheel case leading the water in a much disturbed condition to the wheel. Another fault sometimes occurs in not having sufficient space in the raceway or pit under the wheel for the discharge, causing obstruction and loss of power.

2 A most important and often-neglected point in connection with wheels is the proper design of the draft tubes connected with the

[1] Principal Assistant Engineer, Essex Water Power Co., Lawrence, Mass.

discharge. They are often placed in some available space without regard to its size or direction. With wheels set on a horizontal shaft, as is customary at the present time when possible, long tubes are necessary. Sometimes these are installed with a uniform diameter and set vertically so that the water striking downwards on the bottom of the pit has to turn a right angle to leave the wheel. Examples of this method exist in what are considered model mill plants.

3 The most efficient forms of draft tubes illustrated in Professor Allen's paper are those shown at an inclination and discharging in the direction of the current, with a gradually enlarging area of tube from the inlet to the outlet. The velocity of the water leaving the wheel outlets is necessarily very high and with the enlarging area the velocity may be reduced, with a decided gain in the head derived from the reduction in the velocity of the water leaving the outlet of the tube. The amount of inclination of the tube from the vertical must be considered, and one case comes to mind where the inclination is such that when the wheels are run at part gate a large percentage of the effect of the draft tube is lost, as shown by the reading of the vacuum gages at the center of shaft. At full-gate opening a loss exists, but is not so serious. The inclination of the draft tube to a vertical line through the center of the shaft in this particular case exceeded 60 deg., and was set to avoid removing considerable masonry. Although no fixed rule of inclination or curvature can be stated, it would appear from various cases noted that the inclination should not exceed 45 deg. and all abrupt changes in direction should be avoided. The outlet of the draft tube should be submerged sufficiently to prevent air from entering and destroying the vacuum and the elliptical form of outlet as indicated in Professor Allen's sketch provides area without the necessity of deeper excavation, which a cylindrical tube would require. At Lawrence a slight modification has been used to obtain additional area by building in a rectangular concrete outlet extending beyond the end of the draft tube. It has been the practice to ascertain the height of water as compared with the tail race and, when unreasonable loss is indicated, a leaky packing box or some similar condition is looked for. These gage readings would correspond to the indicator cards of an engine in regard to discovering losses.

4 Our theoretical knowledge of draft tubes, however, is very limited, and the necessity exists for a series of experiments embracing various forms and inclinations of draft tubes, which would give exact knowledge of the best form and the conditions in which they should

be used. A series of vacuum gages attached at various points on the tube, or a water column shown by a glass tube, the upper end connected with the draft tube and the lower end with the water in the tail races, would show what conditions exist in various portions of the tube. A series of experiments in connection with brake tests on a wheel at the same time would add much to the knowledge of the efficiency of wheels and draft tubes.

5 One other point that suggests itself is the importance of the relative velocity of the wheel, or the ratio of the velocity of a point on the circumference of a wheel, to the velocity due the head of water.

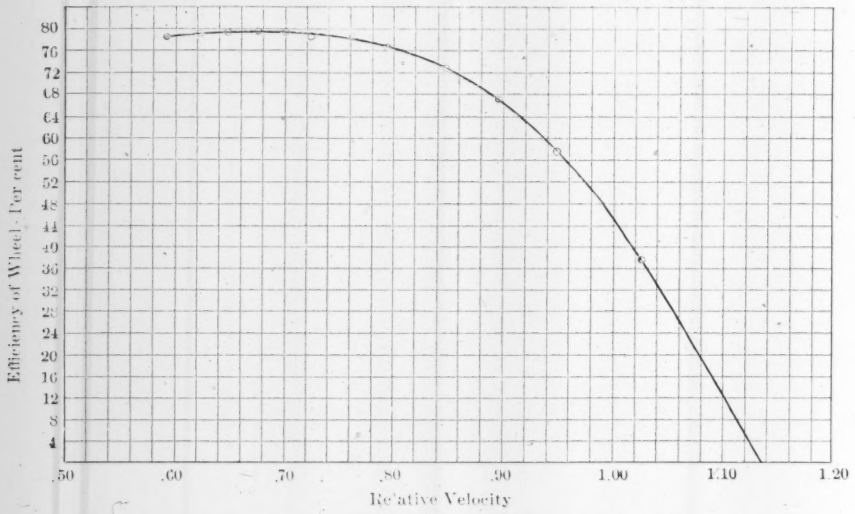

FIG. 1 VARIATION IN EFFICIENCY WITH RELATIVE VELOCITY

By reference to the curves given by Professor Allen (Fig. 14), it will be noticed that there is a speed where the maximum power is obtained, and a falling off in each direction from this maximum. It is important, therefore, to select a wheel that shall run at the proper speed to give the maximum efficiency for the head under which it is to act. For this purpose the average head that exists most of the time would be selected. Under ordinary variations the percentage of loss is not excessive, but when great variations occur the efficiency is reduced materially with a constant speed.

6 Fig. 1 shows experiments made at the Holyoke testing flume on a 48-in. McCormack wheel, the horizontal scale representing the rela-

tive velocity and the vertical scale the efficiency of the wheel by the brake test. It will be observed that from 60 to 75 per cent there is but slight variation in the efficiency due to the change in the relative velocity. As the relative velocity increases beyond this point the efficiency falls rapidly. When at a relative velocity of 1.02 the efficiency is about 39 per cent, and at about 1.13 relative velocity there would be no efficiency. Such a curve is characteristic of this type of wheel.

7 Fig. 2, the practical application of this curve, shows the net horse

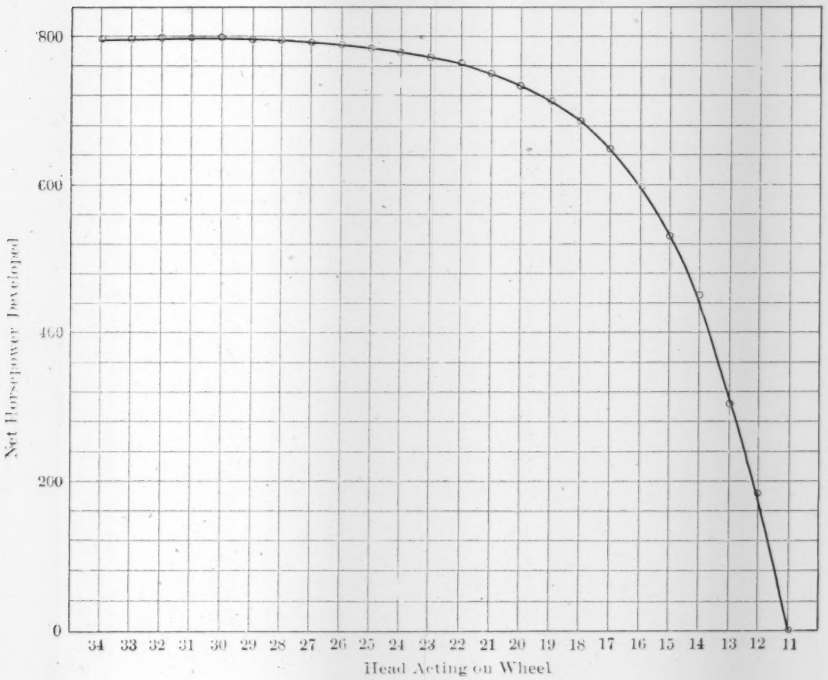

FIG. 2 VARIATION IN POWER DEVELOPED WITH CHANGE IN HEAD

power available from 1000 gross horse power of water with heads from 34 ft. to 11 ft., assuming the speed of the wheel constant and the gate to the wheel wide open. The efficiency of the wheel is assumed as that given by the Holyoke test at full gate. With wheels designed for about 34 ft. the best results are obtained. With a decrease in fall to 20 ft. and the same speed, a falling off of about 50 h.p. occurs, and at 11 ft. there would be no power derived from the wheel. The conditions could not occur on one wheel as the quantity would de-

crease with decreased fall, but there would be a series of wheels added as the head decreases. Reduction of head due to freshets producing back water occurs on all streams, causing loss of power, even with a large quantity of water available.

8 The quantity of water is also affected by the speed of the wheel, and in computing tables of discharge should be taken into account. The examples shown by Professor Allen of discoveries of loss of power by brake tests should be convincing proof to manufacturers and users of power that tests of this character are essential for actual information as to the efficiency of a wheel plant.

9 In connection with the two wheels set on a horizontal shaft and discharging into one draft tube, the results found by Professor Allen are very interesting. The discharge is affected to a considerable extent by the amount of opening of the wheel gates and whether or not both wheels are running. I have had occasion to measure the discharge from a pair of 36-in. Hercules wheels thus situated and at fifteen different gate openings on each wheel. The wheels were run together and then separately, and the combined discharge of the two wheels running together was considerably less than that obtained by adding the discharges when each ran separately. This showed that the confliction of the water discharged with both running reduced the amount that could be discharged. As wheels are run separately in this manner, it would appear that tests on this condition would be desirable.

10 In connection with the measurement of water very excellent results can be obtained under suitable conditions with the current meter. We have made various tests with the current meter, at the same time measuring the quantity of discharge over a weir under excellent conditions (quantities of 400 cu. ft. per second) with variations as low as 3 cu. ft. between the current meter and the weir. Excellent results have also been shown under conditions not as favorable. With the current meter attached to a pole instead of a line, correct results are more certain, and I should have entire confidence in the meter under the fair conditions which exist in flumes and raceways in connection with the discharge of wheels.

JOHN CASTLEREAGH PARKER. The Holyoke tests are very excellent for standardizing wheel practice, but they cannot in the nature of things give exact information as to exactly what the wheel is going to do in the power plant. A great deal of the performance of a water wheel is dependent on the nature of the setting, the intake works

and the draft tube. Those are conditions which cannot be duplicated in any standard laboratory, which the Holyoke plant is in all essentials. The Holyoke flume is not, if I understand the construction of a testing plant aright, adapted to tests on wheels of special shapes. Most of the larger wheels of today are designed for use either as vertical-shaft or horizontal-shaft machines, with spiral casings. The Holyoke flume was designed for and is most applicable to the old barrel type casing. Practically all of the most modern wheels, in the larger sizes at least, are made with spiral casings. Field tests must be made if we wish to know what such wheels will do.

2 Another important value in the field tests is that they enable us to make checks from time to time on the performance of the wheels to find whether the runners are deteriorating. The complexity of the grooves in a turbine runner is so great that it is practically impossible to check the wear, although it might very appreciably cut down the efficiency.

3 Without intending to disparage the use of the dynamometer, I am inclined to question whether it should be designed as a substitute for electric loading. We recently tested three 16,000-h.p. turbines by the electric loading method, which we have found simple and easy to apply.

4 The electrical method provides a considerable degree of security from some of the vicissitudes that Professor Allen has spoken of in connection with his tests. When things go wrong it is simply necessary to close the gates without any worry as to what will happen with the dynamometer. The profession, however, owes a debt of gratitude to the man back of the development of a brake which will enable us determine the efficiency of turbines in those plants where the simpler electrical loading is not available. The paper industries require direct drive and a great many privately owned plants are used to operate manufacturing establishments, such as textile mills, for instance, where power is taken directly from the shafts of the turbines to the shafts in the building. In such cases it is convenient to have a simple and reliable method of getting the loading on the machines.

5 I want to express my accord with what Professor Allen has said in regard to the reacting effect of the design of housings and draft tubes on the efficiency of water wheels. The practice in this country and a great deal of the practice abroad has been vicious in the extreme, in that we have not attempted to put into the design of conduits, housings, and draft tubes even the most elementary hydraulic princi-

ples. American practice has lagged decidedly behind that on the other side in this respect. The old barrel type of housing is execrable, so far as developing efficiency is concerned, especially in the low-head plants, where it has been used almost entirely. We are asking the water to turn at right angles, to change the velocity of flow in passing from sudden contractions to sudden expansions, and to do all sorts of things that no stream of water could readily do.

6 The field tests have no direct bearing on the design of runners. I think the tests made at Holyoke and in the field, however, have helped to improve American runner design and they still have the great advantage of emphasizing the importance in our works of adequate design for leading the water up to and away from the runway. We are indebted to Professor Allen for what such tests as he is conducting will do in that direction and for bringing us to select our wheels more intelligently for the particular heads for which they are to run.

PROF. DWIGHT PORTER.[1] The most desirable test to apply to a turbine is one by which the input and output of power shall be accurately determined under the conditions of final installation. Professor Allen is rendering great service to users of power and to turbine builders by the work he is doing, and it should have generous recognition.

2 Of the three main factors underlying the question of turbine efficiency, namely, volume of water fed to turbine, head acting, and horse power developed, it would seem that the latter two should generally be capable of determination with satisfactory accuracy. Under conditions which sometimes exist at a power station the measurement of the volume of water, however, may be open to material error, and the value of that error seems less easily assignable than at a standard testing station. The pair of wheels referred to in Par. 38 showed an increase of 130 h.p. at 195 r.p.m., when tested after installation, as compared with the amount computed on the bases of Holyoke tests made at a lower head. This means an increase of efficiency of between four and five per cent for the 2600 h.p. developed; but it is easy to conceive of circumstances in which an improper weir coefficient or an imperfect current-meter measurement might lead to an error of at least half that amount.

3 So long as the testing of wheels at a commercial station is

[1]Professor of Hydraulic Engineering, Massachusetts Institute of Technology, Boston, Mass.

common, where the head and conditions of setting are different from those under which the wheels are afterward installed, information of especial value will be afforded by tests such as those just cited, in which the same wheels are first tried out at the standard station and again after permanent installation. It is only by such comparisons that we may get sufficient light upon the error involved in computing from a Holyoke test the proper speed and probable output of the same wheel under a different head.

4 In making such computations it seems ordinarily to be assumed that the various losses of head from shock, friction, leakage and residual velocity will vary in the same ratio in which the gross head varies, and that consequently, the turbine efficiency will remain constant for the same gate opening and same relative speed; while as a further consequence the discharge will vary as the square root of the head. So far as theory goes, it indicates that these laws will approximately hold, but it can hardly be supposed that they will hold rigidly.

5 Even through a standard fixed orifice the discharge seems not to vary strictly as the square root of the head, but is affected by a changing coefficient which must be found experimentally. How, then, can the theoretic law be expected to hold exactly in the case of flow through a revolving wheel with its appurtenances of casing, guides, gate and draft tube. Draft-tube losses themselves are but little known and must be uncertain disturbing influences in many cases.

6 How much the common method of adjusting to a different head the results of a Holyoke test may be in error is only to be learned by comparisons such as Professor Allen carries out. Even though the error be but small in percentage, on large installations it may be a matter of much importance.

PROF. GEORGE E. RUSSELL.[1] One of the greatest stumbling blocks in the path of turbine development in this country has been the lack of systematic testing after installation. Errors in design have been made and perpetuated year after year, simply because purchaser and manufacturer have been satisfied to believe that turbines showing splendid results at Holyoke under a head of 18 ft. or less would give as creditable performances when used with heads five or ten times as great. That this was beyond the limits of reason we know now and should long since have known.

[1]Assistant Professor of Civil Engineering, Massachusetts Institute of Technology, Boston, Mass.

2 Under the low heads which were the first to be developed in this country, it was necessary to meet the demands for increased speed and power by decreasing the diameter and deepening the wheel axially. As the decrease in diameter prevented the free escape of water from the radial inward-flow wheel of Francis, it became necessary to change the shape of the buckets in order to turn the water in them to an axial direction. Thus the Francis wheel was gradually metamorphosed into the vortex type. This wheel has been developed to a high degree under low heads by experimental testing at Holyoke and elsewhere. Very little, if any, of this class of work has been done under high heads, and there are enough reliable data to show that the general type of wheel so far produced in this country is not as efficient as designs from abroad which are based on the radial flow type. As to whether the vortex type can be brought to perfection under these conditions or not there appears to be some difference of opinion, and no intelligent answer to the question can be given until many reliable high-head tests are available. If the answer is to be favorable to the American turbine, then the attainment of this high efficiency can be possible only by development through experimental high-head testing. The shape of the American runner passage is so intricate as to defy mathematical analysis of the water's action, and in this respect at least the European design has much in its favor.

3 The wide and general continuance of the work so ably and carefully started by Professor Allen should be encouraged and advocated by all engineers interested in the highest possible achievements in water power development in this country.

H. K. BARROWS.[1] To improve the efficiency of turbines it is necessary to have an accurate determination of the quantity of water used by the wheel, as well as its power output. Even the standard weir, as it is usually installed under the conditions of a field test, is subject to errors of 2 or 3 per cent or more. Professor Allen showed a view of a large weir installed in a canal for such a purpose and it is evident that the expense of such construction would prevent its use in many cases. Then again, it is often undesirable to create such an obstruction to flow in a canal or tail race. Under such conditions resort must be had to some form of current meter to measure the discharge and the error in determination of flow may rise to 4 or 5 per cent. Ex-

[1]Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology; and of Barrows & Breed, Consulting Engineers, Boston.

cept in unusual cases the field determination of efficiency cannot be made as closely as at Holyoke, and the Holyoke tests will always be valuable as a standard of water-wheel testing. When compared with field tests such as are made by Professor Allen, valuable conclusions can be drawn.

2 Complete field tests, including discharge and efficiency as well as power output, are desirable, not only to bring about improvement in wheel settings and connections but also to insure suitable conditions of water approach and discharge.

3 With some forethought it would be possible in many cases to arrange suitable conditions for current-meter measurements at little or no extra expense, either in the canal or tail race, and in an important water power development this feature of discharge measurements should certainly be kept in mind by the designing engineer. The necessary platform or supports for operating a meter could be provided for at slight cost. A well-designed wheel pit, draft tube, and tail race should afford hydraulic conditions suitable for current-meter discharge measurements.

4 The prevailing idea on the part of wheel users has heretofore been to secure the desired power, oftentimes at a great sacrifice of efficiency, and the testing of wheels in place and at Holyoke is doing much to bring this fact home.

HENRY D. JACKSON.[1] Many of the wheel manufacturers have gone to extreme pains to put their wheels into splendid condition for testing at Holyoke and the wheels have shown correspondingly excellent results, but these conditions would not last long, so that in actual practice the wheels would doubtless show quite different results from those obtained at Holyoke. This has led to the discrediting of the Holyoke tests by a considerable number of purchasers as well as by engineers, especially abroad. To what extent this discredit is well founded I am not prepared to say, but an examination of some of the catalogues, data for which was furnished from the Holyoke flume, leads me to believe that there is reason to question some of the Holyoke tests, particularly when used as they are by some manufacturers. It has been found by actual trial that wheels tested at Holyoke and then shipped elsewhere, for tests, particularly abroad, have shown very much lower results than at Holyoke.

2 As a rule, the purchaser of the wheel desires to know its effi-

[1] Consulting Engineer, 88 Broad St., Boston, Mass.

ciency under all conditions of load at a rated speed. The Holyoke tests, however, as quoted in catalogues, allow the wheel to assume its own best speed under each condition of gate opening, so that the speed neither remains constant nor holds a constant relation to the head. The tests are, therefore, subject to correction, which most purchasers are unable to make. The figures in Table 1, data for which are claimed to have come from the Holyoke testing flume, are quoted from the catalogue of a certain manufacturer, and an examination of a number of Holyoke tests discloses these same conditions.

TABLE 1 TESTS ON THREE SIZES OF WHEELS

	Gate Opening	Speed	Efficiency	Head
A	Full	194.25	81.08	15.29
	7/8	187.75	84.78	16.56
	3/4	178.50	83.88	17.33
	5/8	176.40	80.09	17.54
B	Full	144.00	82.03	15.00
	7/8	138.12	84.55	15.04
	3/4	127.67	83.68	15.11
	5/8	131.50	80.25	15.88
C	Full	109.00	83.58	13.27
	7/8	101.00	85.01	13.79
	3/4	100.00	81.06	14.69

3 The tests start as a rule with full gate and at a rated discharge, and a number of runs are made with different loads and speed. Then the discharge is decreased and another series of runs made. If under full-gate opening the speed which corresponds to the rated discharge of the wheel is noted and attempts made to find under the different gate openings this same speed, it will as a rule be discovered that the speed decreases constantly with decreased gate. Rarely is the full-gate speed maintained or even quoted in the test results on the decreased gate openings.

4 Another reason for so much questioning of the Holyoke tests is the extremely high efficiencies which are sometimes quoted. For instance, a short time ago it was reported that a certain wheel showed approximately 94 per cent efficiency at the Holyoke flume. The theoretical efficiency of a water wheel would rarely exceed 97 per cent and theorists on water-wheel design claim the losses vary from 12 per cent upwards, so that such efficiencies seem to be very questionable, unless the theorists are mistaken in the value of the various losses.

The wheel manufacturers do not as a rule guarantee their wheels at over 80 per cent efficiency and this would seem sufficient reason to believe that they themselves do not place too much reliance on the results obtained at Holyoke. There are times, however, when wheel manufacturers will guarantee considerable increases over 80 per cent. But I am strongly inclined to believe, partly from experience, that they will balk when the purchaser asks that this guarantee be placed on paper, that the wheels be tested, and that a bonus and forfeiture clause be put into the contract. For these reasons, it seems to me decidedly advisable to test the wheels under conditions of installation, and the device used by Professor Allen appeals to me very strongly.

5 It is, however, open to some objections. Unless used with extreme care it would seem as though the results would be higher than the actual conditions of the installation should show. Suppose a generator be removed from the water-wheel shaft and a dynamometer be substituted. If the dynamometer be carefully balanced so that none of its weight is taken by the water-wheel bearings, is it certain that some of the weight of the water wheel is not removed from its bearings, thereby reducing the friction? In many cases the water wheel is fastened directly to a coupling on the generator shaft, so that the water-wheel bearing is also the bearing for the generator. At the same time, however, a large part of the friction on this bearing should properly be charged up against the water wheel, so that it is important in using this dynamometer to be sure that the bearing friction of the wheel is the same as it will be when the wheel is in actual service. This point being assured, the test, so far as the actual power delivered by the wheel is concerned, is a relatively simple matter. In case the water wheel is belted to lineshafting or any user of power, or in case it may be connected by gearing, the use of the dynamometer does not throw the same thrust on the bearings as exists where the wheel is actually doing its usual work; and as the power delivered by the wheel should take into account the losses in its bearings under conditions of actual service, it would seem to me as though the dynamometer test would show higher results than should reasonably be expected.

7 In making the tests certain errors exist outside of the dynamometer. These are in the measurement of the water and the measurement of the head acting on the wheel. The water in many cases may readily be measured by means of a weir and if the weir is properly proportioned the measurement may be quite accurate. It is seldom possible, however, to use a weir of standard dimensions and any change in the form will introduce errors of greater or less magnitude. The

head acting on the wheel will be affected by conditions of setting, methods of getting water to and from the wheel, the shape of the penstock and draft tube, and the location of other wheels near that under test. On very high heads there is also a possibility of considerable error in determining the actual head working on the wheel.

8 I am glad to know that Professor Allen believes the test made by the use of the electric generator as a basis of measurement of the power delivered by the wheel is perfectly satisfactory. The efficiency of an electric generator can readily be calculated under practically all conditions of load and there should be no trouble in the use of the necessary instruments for determining the output of the machine. The effects of temperature or magnetism can readily be overcome and the error in the instruments to a large extent eliminated by the use of duplicates and care in handling the instruments in transportation and in service. The question of absorbing the power generated is a very different matter, as frequently it is difficult to design the apparatus necessary to absorb very large amounts of power without very great fluctuations. The water rheostat, while valuable in service, is not always easily controlled; nor is it always easy to vary the load of a generator over sufficiently wide ranges and speeds to give all of the characteristics of the water wheel which may be desired. These characteristics, however, are of service only to the investigator and the designer of the wheel and are not strictly for the purpose of determining whether the wheel is or is not up to its guarantee.

9 One of the great advantages in the use of the generator as a method of testing is that it is a permanent part of the installation, available for tests at all times, thus enabling the owner to check up the efficiency of the wheel and the conditions of installation and to determine whether or not anything has arisen to reduce this efficiency, or whether changes in the plant have in any way affected it. This is sometimes an important consideration.

10 In conclusion I would like to ask if there are not chances for error in the calibration or measurement of the brake constants.

H. C. DAGGETT. At the present time there is probably no feature of a hydraulic plant about which there is so little definite data as in connection with draft tubes. One reason is that no testing flume exists today which is suitably arranged and designed for making tests of draft tubes of different sizes and shapes. When water wheels are tested in place certain results as to power and efficiency are obtained. but there is no means of knowing to what extent these results are due

to the design of the draft tube. For example, a pair of water wheels may be tested in place with a certain kind of draft tube and may give good results, while another pair tested with another type of draft tube may give poor results, but we do not know that the difference in efficiency was entirely due to the difference in the design of the draft tube. It may have been due partly to the draft tube, to the difference in the actual efficiency of the water-wheel runners, to the way in which the water enters the wheel case or flume, to the difference in the design of quarter-turn or center case, to the number and design of bearings, or to other details. In other words, the actual tests in place are so comparatively few, and the conditions apart from the design of draft tube are so seldom alike, that it is safe to say that we seldom or never test two units of water wheels where all the conditions except the draft tube are the same.

2 Therefore, each designer of water wheels uses his own ideas as to the proper form of draft tube to be used in any particular installation. He is influenced, of course, by the conditions to be met and by his own personal experience. He may design a draft tube with a view to saving rock excavation or, in case of a renewal of water wheels, to avoid changing the old wheel pit. In the case of horizontal water wheels, he is often influenced by the necessity or desirability of placing the elevation of the wheel shaft above tail water in time of freshet. Oftentimes, however, he has the choice of several different designs of draft tube, and it is difficult for him to know just which particular design would give the most efficient result. Some writers on hydraulic subjects have given tables showing the length of draft tube which may be used with different diameters of tubes. These tables, however, are arbitrary and are simply one individual's idea in regard to that particular point. The writer believes it is true that, everything else being equal, a vertical, conical draft tube will give greater efficiency than one built to any curve or set at any angle with the vertical. On the other hand, a draft tube that leaves the water wheel vertically and discharges horizontally in the direction of discharge of the tail race eliminates loss of head in the wheel pit to a large extent, and in many cases the gain in head would no doubt offset the greater efficiency that might be obtained with the vertical tube. Lack of information on this point, however, makes it impossible for us to say in any given case which would be the more efficient design and how much more efficient. Again, by constructing a draft tube at an angle from the vertical oftentimes a certain amount of excavation can be avoided but it is impossible to say whether the loss in efficiency by so doing is compensated for by the saving in the cost of excavation.

3 Some engineers have maintained that a properly designed draft tube should have a certain fixed angle of flare, regardless of the length of tube, velocity in the tube, or other conditions. The writer has had access to certain experiments on small tubes, however, which indicate that the best angle of the tube depends on the length of the tube, the velocity of the water in the tube, and the head under which the water wheel is operating.

4 It would certainly be very desirable if a testing flume were available where careful experiments could be made of the results obtained with different designs of draft tubes, where at the same time all other conditions could remain the same, showing that the difference in results was entirely due to the difference in draft tube design. Such tests would be invaluable and the writer hopes that arrangements may be made in the near future whereby such a testing flume may become available for the use of engineers, users and builders of water wheels.

SYMPOSIUM ON ELECTRIC DRIVING IN MACHINE SHOPS

The paper by A. L. DeLeeuw on The Economy of the Electric Drive in the Machine Shop, published in The Journal for November 1909, resulted in the holding of a joint meeting of the Society with the American Institute of Electrical Engineers in the Engineers Building on April 12, 1910, on the general subject of Electric Driving in Machine Shops. In addition to Mr. DeLeeuw's paper, three others were given, one by Charles Robbins on Electric Motor Applications, another by John Riddell on Mechanical Features of Electrical Driving, and a third, contributed by the American Institute of Electrical Engineers, by Charles Fair on Motor Application to Machine Tools. The same papers were discussed at a joint meeting of this Society with the St. Louis Section of the American Institute of Electrical Engineers and the Engineers Club of St. Louis on April 9. Brief abstracts of the papers and the discussion on them follow.

THE ECONOMY OF THE ELECTRIC DRIVE IN THE MACHINE SHOP

By A. L. DeLeeuw, Published in The Journal for November 1909

ABSTRACT OF PAPER

This paper calls attention to a number of factors affecting the economy of electric drives in the machine shop, but makes no attempt to give figures or formulae by which the economy could be computed. On the other hand, it attempts to show why such figures or generalizations cannot be of any value at the present time. This is due partly to the lack of reliable data and partly to the fact that much of the benefit of the electric drive comes in a form which makes it unfitted to quantitative analysis. The paper further shows that each problem of installation or conversion must be treated by itself and proceeds to show which elements are mainly to be considered.

MOTOR APPLICATION TO MACHINE TOOLS

By Charles Fair, Published in the Proceedings of the American Institute of Electrical Engineers for May 1910

ABSTRACT OF PAPER

This paper discusses the advantages of the individual electric drive for machine tools, with special reference to tools which are already in service

with belt drive. In such cases it is necessary to consider in choosing a motor, the nature of the work, the speed changes required, the number of tools thus to be equipped, and the condition of the tools. Even where a motor is applied to a tool designed for belt drive, the new drive should be simple in construction, satisfactory in operation, and sightly in appearance. Numerous methods of attaching motors to old tools are shown and described.

The choice of control, whether it be with old or new tools, is fully as important as the choice of the motor and it is necessary to consider the accessibility of the controller to the operator, the method of attaching it to the tools, and its relative position to other tools. Accessibility in case of accident is an important consideration and the starting compensator should be placed where the motor or some of the moving parts can be seen by the operator. Wherever possible, both controller and motor should be attached directly to the tool. In the case of portable tools this is an absolute necessity. The effect of convenient control upon the output of the tool is emphasized and various types of controllers and methods of application are shown and described.

A table is attached which is designed to aid in a general way in the choice of motors, and numerous methods used to maintain standard motor shafts are illustrated.

ELECTRIC MOTOR APPLICATIONS

By Charles Robbins, Published in The Journal for April 1910

ABSTRACT OF PAPER

In this paper are outlined the uses of a graphic recording current-meter in connection with individual machine tool drives, in showing actual working time, in detecting delays from any cause, in checking the rate of removing metal, and in establishing and maintaining the rate for maximum economy.

The relative merits of the lineshaft and individual motor drives are discussed and a table given showing graphically the superiority of the latter.

The five appendices supplement the paper and pertain to the following subjects:

a The characteristics of various machine tools as shown by diagrams from recording meters.

b Data on the power required to remove metal under the conditions set forth in the appendix, together with convenient charts for determining the various factors mentioned.

c A summary of the average horsepower equipment for different types of tools and the approximate speeds of the motors which are normally selected for this work.

d Calculations to determine whether it is more economical to equip an old machine with a motor or to purchase a complete new motor-driven equipment.

e Over-head charges and machine hour rates.

MECHANICAL FEATURES OF ELECTRIC DRIVING IN MACHINE SHOPS

By John Riddell, Published in The Journal for April 1910

ABSTRACT OF PAPER

This paper is principally devoted to the various mechanical means employed in attaching individual motors to machine tools, with particular reference to the practice of the General Electric Company. Each of the common machine tools is treated separately and illustrations are given of the mechanical devices employed in attaching the motors. Several auxiliary devices are described, such as muslin pinions to prevent noise in gear trains, and rubber buffers between the gear and the driving spindle to prevent chattering on finished cuts.

DISCUSSION AT ST. LOUIS

M. L. Holman. There is no business of any kind where there is no ready-to-serve charge. The difficulty arises in this country from our adoption of the English system of estimating and accounting before the people were ready for it. In England the charge is called the standing-by charge. The same thing appeared in this country as a ready-to-serve charge and met with opposition everywhere. The charge is a just one, but is not generally understood. All concerns that do not go to the wall have that item in their charges somewhere.

2 I wish to call attention to the fact that as our machinery develops we go from the pioneer stage into a higher degree of civilization and our machine shops as well as our engineers have to stop making things and manufacture them. The young men of today are the men who must operate the country that has grown to an extent where the operation begins to be visible. The building of a pioneer country is an entirely different proposition. Germany has come to a point where it is almost entirely a question of operation. If they do not manufacture more cheaply than other people they will starve to death and some of the other European countries are in nearly the same position. Of course it will be years before this country must face such conditions, but we are just entering that stage of our engineering progress where we must begin to manufacture things and stop making them.

Prof. W. F. M. Goss. A few years ago it was commonly believed that the electric motor could only be used under certain favorable

conditions. If there are any who today hold such an opinion, they should visit the great steel works at Gary, Ind., where not only machines but compressors and roll trains are electrically driven, to be convinced that there is nothing in machine driving that can not be done by the electric motor.

2 A modern machine shop, whether for repairs or manufacture, presents an equipment of specialized machines. The capitalization which underlies the operation of the shop has been extended enormously in these later days, and the added cost of a motor to drive an individual machine is now more easily met than formerly. If the layout of the shop is properly balanced and if there is business sufficient to keep the machines going, an individual motor for each machine will increase the output and improve the efficiency of the shop.

3 I do not believe that there are many cases where it will pay to fit motors to old machines. There may be individual cases where this may profitably be done, but the new motor and the old machine will always be less efficient than a complete new outfit. If a point is reached in the development of a shop when electrification is in order, it will generally pay to provide new machines which will be up to the standard of the motor.

4 I am convinced that the machine tool of the future is to be an individual motor-driven machine, a machine in which we will not see pulleys, belts, or gears. Such a machine will not only be powerful, ready for instant service and easy to maintain, but it may be taken from its station if desired and moved to its work. It will be an instrument which, because of these facts, can be used in the development of a much larger output than will be possible by machines of the ordinary characteristics.

E. R. Fish.[1] There are probably few manufacturing plants designed at present which do not provide in a greater or less degree for electric transmission of power. In many instances provision is made for a generating plant, but sometimes it is more economical to purchase current from a central station. My own experience has been in connection with a shop for the manufacture of boilers. In plants of this kind several methods of power transmission are required, but a great many of the tools can best be driven by motors. In fact the use of motors permits the only rational layout of a shop of this sort or economical production. Any other form of motive power can be

[1] Secretary, Heine Safety Boiler Co., St. Louis, Mo.

used only at great inconvenience, with poor economy, and with large maintenance charges. With motor drives the machines can be located exactly where they are wanted and where the successive operations will progress without unnecessary handling or delay. We use the 220-volt, 3-phase, 60-cycle current and have found it e tirely satisfactory. It drives plate-working tools of all sorts through individual motors, drives a small machine shop through a lineshaft, and operates a 25-ton traveling crane. In our case it was quite impracticable to use power from a public-service station because our processes required a power house of our own. We did want an emergency connection from the outside in order to provide against possible failures of our own generator but the ready-to-serve charge was quite prohibitive. A large portion of our work is done by hydraulic and pneumatic tools, so that even though the generator should fail, the works would not be entirely shut down. It is therefore unnecessary that this charge be incurred. It is undoubtedly true that in many instances the protection against break-downs which would completely close the plant would justify the cost of such an outside connection.

A. H. TIMMERMAN.[1] The choice of direct or alternating current for machine shop drives depends largely upon whether there is a possibility of throwing over to a power company's circuit. If the ready-to-serve charge is not too great, the alternating-current distribution is by far the best, because in case of failure of supply the alternating current of the power company can be relied upon.

2 In the case of an individual installation in which the amount of power required is large and there is no public service corporation to rely upon, the question of direct or alternating current is largely a question of the area covered by the plant. Alternating current is satisfactory for both small or large plants but direct current is hardly suitable for a plant extending over a considerable area because of the large drop in voltage due to the long lines required.

3 Six or eight years ago a great deal was heard about adjustable speed motors for all forms of machine tool drive, but machine tool builders have found it necessary to build their tools so as to get the necessary changes in speed mechanically.

4 I was rather surprised that emphasis was placed on the squirrel-cage polyphase motor. There is an increasing demand on the part of the power companies for the wound-rotor type. The squirrel-cage

[1] Superintendent, Wagner Electric Manufacturing Co., St. Louis, Mo.

draws a very heavy current at starting in comparison with that used by the wound-rotor type. With the latter type full load torque is obtained with full load current, or double torque with double current. The squirrel-cage type requires for full load torque from two to four times full-laid current, depending upon the design of the motor.

5 In this connection it is also of interest to note that the single-phase alternating-current motor can be used just as well as the poly-phase motor for tool drive. In fact in many installations it is much better because a single-phase motor, starting on the repulsion principle, has an exceedingly high torque and draws very much less current from the line for a given torque, than is drawn by any other type of motor.

6 The amount of power drawn for any tool varies from one-tenth full load to a load and a half, and a motor must be put on an individual tool which will take care of the largest load that the tool is liable to have. On the other hand, if five or ten tools are grouped together, a motor that is perhaps a quarter of the sum of the individual horse-power capacities required on the different tools may be installed. This is shown by the fact that even where a group drive is used, the actual power drawn from the generator is very often not in excess of 40 to 60 per cent of the total horsepower connected to the generator.

7 In the installation of alternating-current motors care should be taken that motors not too large for the work are chosen. The alternating-current motor has a very much heavier overload capacity than the direct-current type, and since the power factor at fractional loads is rather low, it is better to have alternating-current motors overloaded than underloaded.

P. A. Morse.[1] If it is necessary to use alternating current from the source of power it is very frequently advisable to put in motor-generators to take care of machine tools or of hoist motors in such a way that a much better power factor is obtained, thereby decreasing the watt load and increasing the capacity of the generating units. The Grand Trunk shops have some large motor-driven compressors to which are coupled synchronous motors. At a plant in St. Louis in which the power factor was very low, the slip-ring type of alternating-current motors was used for certain work. When these were changed recently to direct-current, it increased the power factor and the capacity of the generating plant.

[1] Engineer, Western Electric Co., St. Louis, Mo.

2 While alternating-current motors, both single-phase and polyphase, have in recent years been adopted very widely as sources of power in the machine shop, the fact still remains that with a class of work which calls for mechanically different sizes of material to be passed through and where the processes on a given machine tool are not the same from day to day, it will be almost imperative to use the direct-current motor.

3 Recent practice in direct-current motors is to furnish them with inter-poles to improve the commutation and the advantage claimed for the alternating-current motor, that it gives less trouble, should not be as much of a factor hereafter.

4 The alternating-current motor, of course, has practically only the bearings to look after, but the narrow air-gap, which is necessary in order to correct certain other things which make the motor undesirable, must be balanced against commutator trouble. Within the last few years considerable work has been done in battering the commutation of motors. This fact has not been generally recognized but will have its bearing on future installations.

H. H. HUMPHREY.[1] In connection with stand-by service from a public utility company, it is often an advantage to be able to start part of the plant before the power plant is ready. I know of one case where the entire plant ran for about three months on central station power. This service has been abandoned this year because it was found that the isolated plant is much more reliable than the central station service in this particular case.

2 As an industrial plant grows in size, it generally puts in reserve capacity, which is kept ready to serve, while on the other hand the central station companies are generally overloaded. If they are not this year, they will be next, for the reason that they connect more customers than their total capacity.

O. STEPHENSEN.[2] There are one or two points on which I would like to take issue with Mr. Morse regarding the relative merits of direct and alternating-current motors. There are many cases in which a constant-speed motor can be used, especially for quantity manufacture. Only where the work changes from one job to the next or from moment to moment is an adjustable speed motor required.

[1] Consulting Electrical Engineer, Chemical Building, St. Louis, Mo.
[2] Electrical Engineer, Wagner Electric Manufacturing Co., St. Louis, Mo.

2 I also take issue with the objection made to the alternating-current motor because of the small air gap. Even with an air gap of only a few thousandths of an inch, proper care, which means nothing more than the right kind of oil in the bearings and the right amount at the right time, will prevent the rotors wearing on the stators, if the bearings are designed liberally enough. The latter point is therefore a very important one to the purchaser of an alternating-current motor.

WILLIAM H. BRYAN. The State Railway Commission of Wisconsin has been doing some admirable educational work towards a better understanding of the ready-to-serve charge. They are fixing rates for all the utilities in that state, and are doing it very thoroughly and well.

2 I do not like Mr. Robbin's method of charging depreciation as outlined in Appendix No. 5 of his paper. This method, which he says is in general use in appraising shop tools, is to charge off a certain amount each year. He gives it as 10 per cent, which I find a very common figure. The next year they charge off 10 per cent of what is left, the next year 10 per cent of what is left of that, and so on, so that tool may be thirty or forty years old and still have book value.

3 The more modern way of handling depreciation is the sinking-fund scheme, by which the probable life of the tool is first estimated, by a study of its service, and then an amount is set aside each year, which will, with interest compounded annually, at the end of the assumed period of life, have replaced the full value of the tool. To ascertain the value at any intermediate date the amount of the accumulation in that fund is deducted from the cost of duplicating the tool.

PROF. H. WADE HIBBARD. I recently visited the St. George Street plant of the American Car and Foundry Company in St. Louis where electric driving is applied to a wide range of work. That plant, engaged in the manufacture of steel cars, is very large and compact. Since it is engaged in the manufacture of a large number of parts that can be produced on a factory basis, they have adopted alternating-current motors. The large machines are individually driven, and the small machines are group-driven. One is impressed in such a plant with the change that has come about in machine shop practice in recent years.

DISCUSSION AT NEW YORK

CHARLES FAIR.[1] It. is disappointing that so many of the tool builders fail to take advantage of the increased production which would result from proper attention to the convenience of control. There are many cases where the tools are so arranged that the control might easily be damaged by trucking, etc., or sometimes the control is placed 40 or 50 feet away from the motor, necessitating considerable useless wiring. Others often place the operating handle in such a position as to make it a back-breaking job for the operator.

2 For electrical reasons it is of course not practical to build motors with a ratio so great as 15 to 1, nor can I agree with Mr. Eberhardt that such a large ratio would be desirable or necessary for a large majority of the work. The question of standardization of speeds and principal dimensions is not impossible, but that the tool builders would be satisfied with such a standard is not at all probable, inasmuch as there is a decided difference of opinion among them both as to speeds and shapes of motors.

3 An unfortunate circumstance which often surrounds discussions relating to electrical apparatus for tools is a lack of knowledge on the part of either side of the limitations and requirements of the other. Much of the trouble which tool builders are experiencing today could be eliminated were they to discuss their difficulties more freely with men who are conversant with both sides of the subject.

HENRY HESS. I cannot agree that the direct-connected motor drive is always and everywhere the only correct thing; nor do I reject it absolutely and utterly for every shop, place and tool. Both attitudes are too radical and sweeping; truth will be found as usual between the extremes.

2 The direct-connected motor drive is distinctly preferable where any advantage in quantity of output results from its use, or where a machine is to be portable, or so located that it can be reached only by long or awkward lineshaft and belt drives. Under every other condition the individual motor drive is more expensive in initial installation and upkeep, and more complicated to maintain in the average shop.

3 The absence of overhead and vertical belting is an advantage that appeals to the extremist. The amount of light obstructed is

[1] General Elec. Co. Schenectady, N. Y.

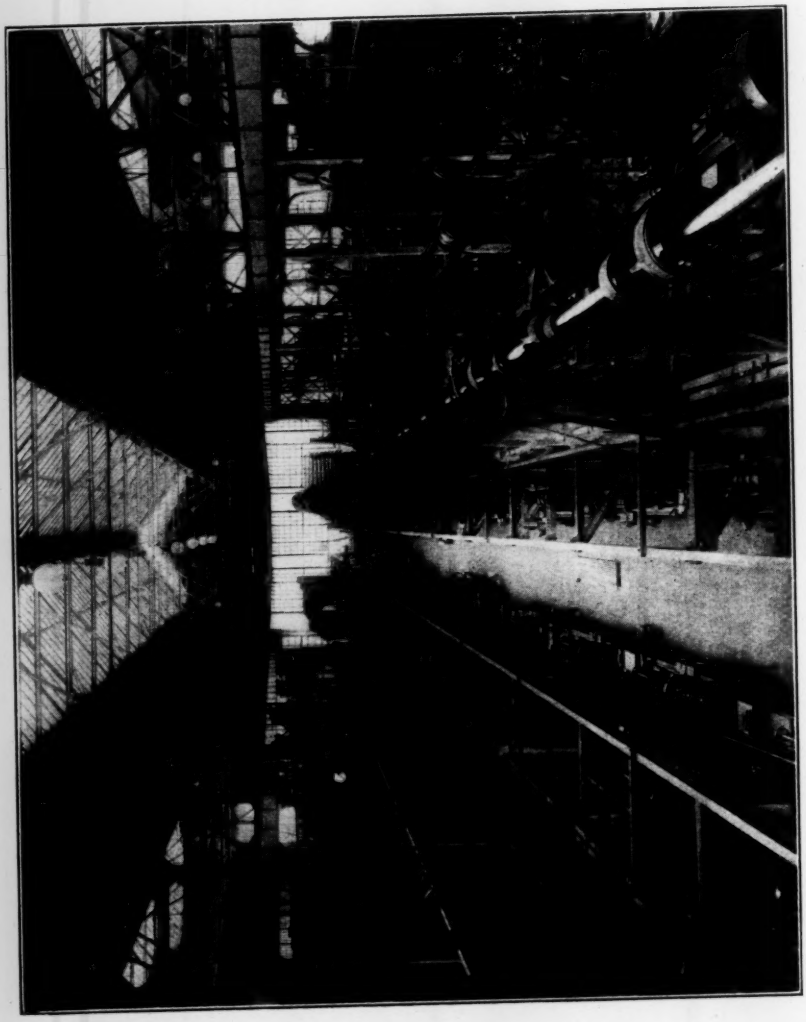

FIG 1 BELT-DRIVEN MACHINE SHOP FROM ABOVE

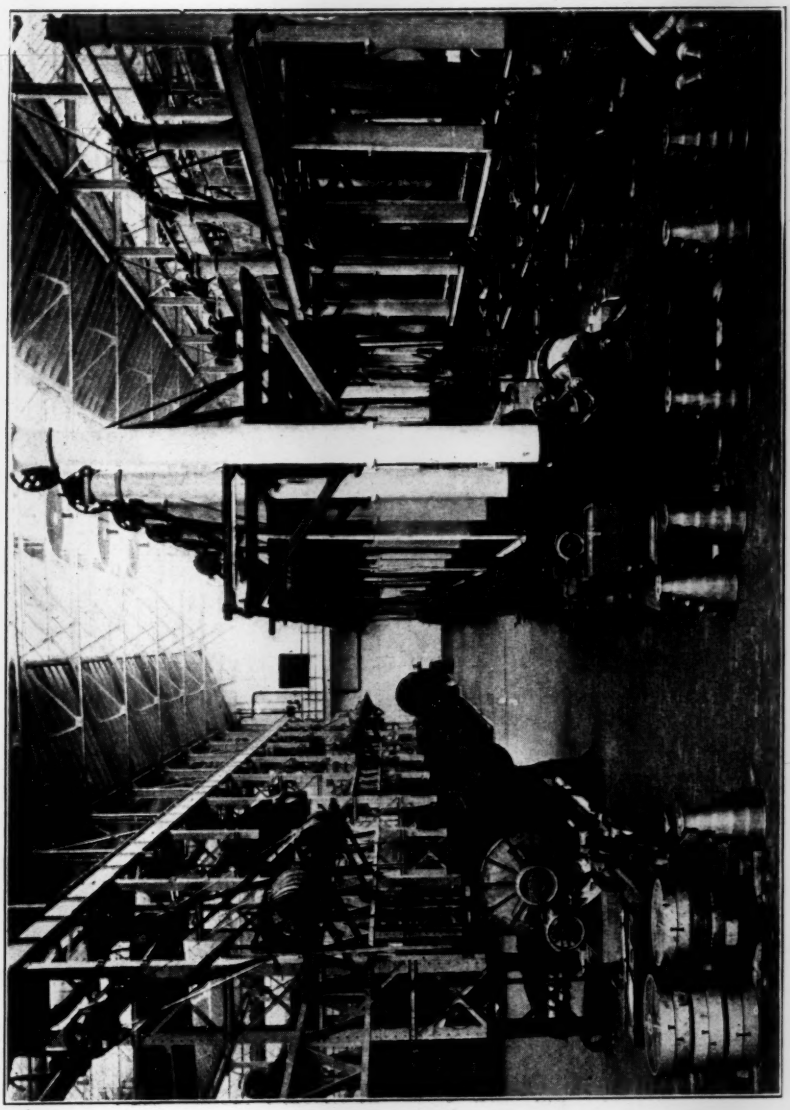

FIG. 2 SAME AS FIG. 1 FROM BELOW

inappreciable, be the shop of the modern well-lighted type or one or the older dark interiors. The horrible example which Mr. Riddell shows (Fig. 1) is most carefully selected; but is not necessarily representative. In contrast note Figs. 1 and 2 herewith. Here are six parallel rows of lathes in a shop bay 50 ft. in width. The two side rows are driven from lineshafts carried on the crane columns. The four central rows are driven from two lineshafts that are mounted on cast-iron columns standing free of the building. Cross-arms from these support longitudinal channel beams to which the countershaft hangers are attached. The lineshafts are driven by alternating-current motors back-geared to the shafts. Note also the utilization of the crane-track girders for carrying the lineshaft that drives tools close to the crane columns. These lineshafts are also direct motor driven. There is no interference with the overhead traveling crane. Not the most rabid advocate of light has ever been able to criticise this installation for lack of it. Nor is there any noticeable interference with lighting when there is an overhead ceiling as in Fig. 3. Here again the lineshaft is driven by a motor attached to the ceiling.

4 Even eliminating all of the many establishments that could not fairly be classed as progressive, provided the test of progressiveness is not based on the direct-connected idea, an examination of the machine shops in a given city will fail to show the prevalence of the direct-connected individual drive, whether the comparison be made on the basis of number of shops, of machines, or of power transmitted. The conditions found in one city will be found true of others and of the country districts as well. The lineshaft and belting manufacturers are not yet losing sleep or going into the hands of receivers.

5 In the average machine shop, increase of capacity is, as Mr. Dunn quite correctly points out, of prime importance. Whenever increase in capacity is directly attributable to the individual motor drive, that should be installed; but in each case it should be carefully considered whether the same increase in capacity cannot be secured without it. Then the relative cost of initial equipment and maintenance should be the deciding factor.

6 That shop manager not interested in what his operation costs is likely soon to receive emphatic reminder that his lack of interest is not shared by those whose dividends are affected. Every possible saving should be taken advantage of every element of cost should be reduced if possible.

7 As producing engineers, we are all necessarily interested in advocating the particular thing we produce or help to produce. So

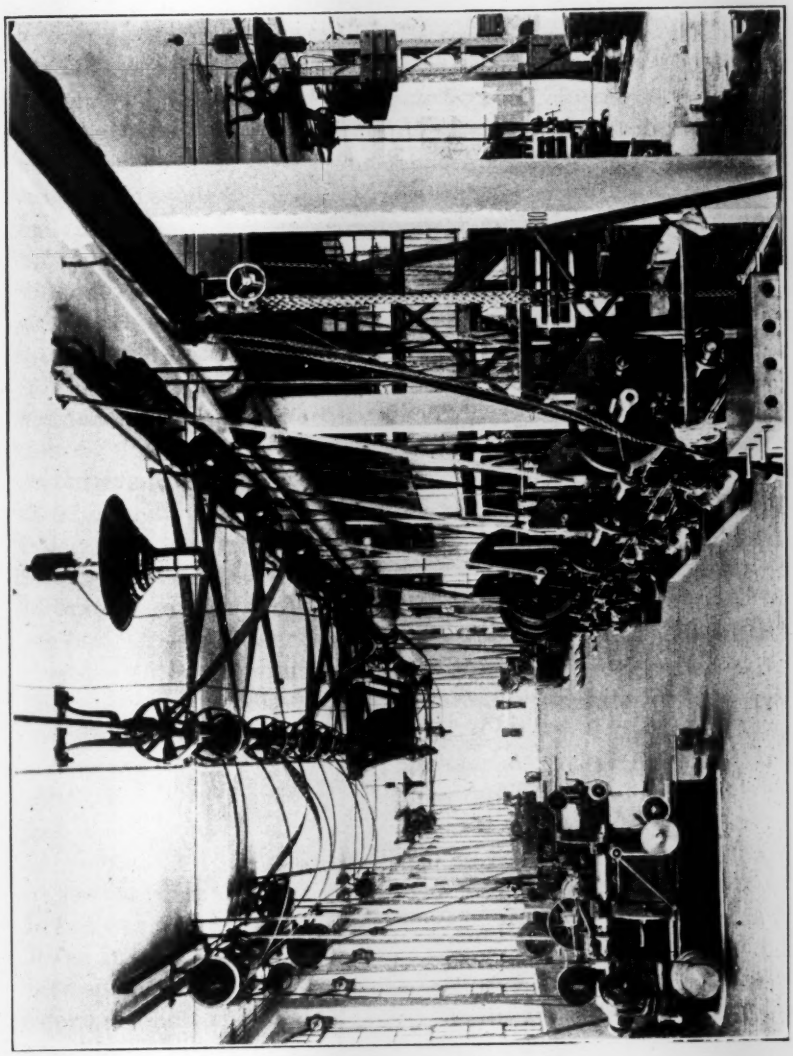

FIG. 3 BELT-DRIVEN MACHINE SHOP WITH CEILING

far as my advocacy of the ball bearing is concerned that does not predispose me toward the ball-bearing lineshaft, for the simple reason that the ball bearing is quite as widely employed on electric motors as on lineshafts.

8 Can the most thorough-paced advocate of the electric motor claim for it that it delivers more power than may be transmitted through a belt? Should one be found possessed of sufficient temerity, then what explanation has he to offer for that species of direct-connected motor drive in which a belt is interposed between the motor and the machine? Many such are to be found in the shops of the best-equipped motor manufacturers, who, believing in the most thorough way in adopting what they advocate for others, equip throughout with motors to the exclusion of all lineshafts. Certainly these manufacturers and their shop managers do not go to the length of sacrificing capacity merely to be consistent. But they get that result in many cases through belts, and even through belts plus the despised countershaft, with the motor thus twice removed from the direct connection (see Figs. 5 and 9 of Mr. Riddell's paper).

9 Moreover, with belt drive the machine-tool manufacturer can build his machines in large lots without having to individualize for the almost endless diversity in electric motors. Attention has been called to the difficulties of reconciling the diametrically opposed needs of the electric motor and the machine tool. All of these difficulties are solved by the gear box already in more or less general use by many machine tool builders. It may be driven by either a direct-current or an alternating-current motor or by a belt from a lineshaft or countershaft. All it asks is that the motor or belt be of sufficient size to satisfy its hunger for power.

10 A motor is many times more costly than a belt, wastes far more power in journal friction and windage alone than the belt uses up, and in addition has great electrical losses. Mr. Robbins, in advocating the motor, admits a motor waste of one horse-power to every three usefully delivered. What belted drive can be accused of similar wastefulness and inefficiency? Remember also that the belt drive does not vary in speed even by a few per cent. Can that be said of the electric motor? Even its advocates have admitted the contrary.

11 Great credit is due the manufacturers of electric machinery for having given an impetus to the art of economical machine production. They have not only stimulated the advance through constant demand on the machine tool builder but they have also shown him the way by example. Naturally they have made the widest possible

use of that means of power transmission which constitutes one of their staples of manufacture. That has focussed attention on the methods they advocate. Other methods no less meritorious, or even superior, with no such strenuous and interested advocates have not been similarly brought to public attention, and possibly have not felt the need.

12 The essential matter which the man responsible for final costs must weigh is not that of direct-connected individual motor drive, or of any other drive, but the one of final total cost as influenced by all factors. So far as the transmission and application of power is concerned, it is a matter of largest output at least cost. It must be by motor if that gives more output than can be realized by shaft and belt. It must be by shaft and belt if that can give as great an output as the motor. The decision must so fall, simply because of lower first cost and lower upkeep cost.

13 Stress has been laid in the papers on the economical features of the direct electric motor drive. Whenever such application results in increased output, due to qualities inherent in the electric motor, then the direct motor drive is in order. Whenever the direct motor application does not inherently reduce operating time, then investigation is in order to determine whether the lineshaft drive is not more economical and the direct motor application a compliance with a fad to be dearly paid for.

14 The impression given by the papers is one of the all-round superiority of the direct-connected motor. It is only in the following instances, however, that the individual motor drive over-balances the economic features of the lineshaft:

a Where machine portability is important.

b Where relative under-equipment with large machines makes their overtime operation necessary, while the balance of the plant is idle.

c Where occasional machines can be reached only by long lines of shafts or are inconvenient to drive from the lineshaft.

d Where the direct motor application results in increased productive output not otherwise obtainable.

15 In every other case the lineshaft has the advantages of lower first cost, lower cost of maintenance, smaller depreciation, less power waste and less grand total of annual costs.

16 Moreover, the differences are very decided. This is true even

when the lineshafts are mounted on plain bearings with their large friction wastes. It is still more true when these friction losses are reduced by mounting the lineshafts on ball bearings of a durable type. The difference is still further increased in favor of the lineshaft when it is run at the high speed that ball bearings make feasible. High speed decreases weight of shafting, weight of pulleys, weight of belts, and with these the journal loads and losses, as well as the first cost of every element in the system.

17 Realizing that definite figures rather than general statements are wanted, I have made direct quantitative comparisons, using as a base an existing, well-arranged plant of direct motor-driven machine tools. For this purpose our former president, James M. Dodge, placed the data and experience of the Link Belt Company's works at my disposal.

18 Fifteen representative machine tools cost for motors $4,920; for power annually at $0.03 per kw-hr. $2,930; for depreciation at 10 per cent and maintenance at 5 per cent $492 and $246 respectively. The total annual cost is $3,868.

19 A line shaft installation at 200 r.p.m. on plain bearings would cost only $520 initially and take $170 less annually for power, with a total annual cost of only $2838, or $830.00 less.

20 The same lineshaft, but carried in ball bearings would cost only $790 initially, save $330 in power annually and involve a total annual cost of only $2718, or $950 less.

21 Increasing the lineshaft speed to 600 r.p.m. and carrying this in ball bearings gives the most economical arrangement at an initial cost of only $460, an annual power charge reduced by $750 and a total annual cost of but $2249, or $1419 less.

22 Such a high-speed ball-bearing lineshaft system costs less than one-tenth as much to purchase as a direct-connected individual motor system, while involving less than two-thirds the latter's annual charges. Even this can be bettered materially by the employment of ball bearings in the countershaft and loose pulleys.

23 The data on which the foregoing is derived are given in detail in the appendix herewith, based on the tabulation in Table 1 of direct-connected machine tools in the shops of the Link Belt Company's plant, at Philadelphia.

APPENDIX TO DISCUSSION BY HENRY HESS

TABLE 1 DIRECT-CONNECTED MACHINE DATA

Motor No.	Motor Rating Horse-Power	Load Factor Per Cent	Motor Cost Dollars	Machine
43	25	14.4	583	120 in. Vertical boring mill
42	25	12.0	588	84 in. Vertical boring mill
76	9	16.6	268	37 in. Vertical boring mill
99	9	16.6	268	30 in. Vertical boring mill
100	9	15.6	250	Keyseater
61	3	20.0	159	Drill press
60	8	27.5	303	Keyseater
72	8	21.3	237	Keyseater
46	18	20.0	477	20 in. × 49 ft. lathe
44	12	8.3	440	30 in. × 27 ft. lathe
62	3	16.7	159	Cut-off lathe
104	12	14.2	440	Milling machine
39	9	36.5	263	Planer
59	8	18.8	237	Side planer
66	9	15.5	250	Screw cutter
Total	167	17.0	$4923	

24 As the total load factor in Table 1 is 17 per cent of the total motor rating, the total useful power delivered is $167 \times 0.17 = 28.4$ h.p.

25 In Par. 24 of his paper Mr. Robbins allows for the low load factor of direct-connected motors by assuming an average motor efficiency of 75 per cent. But this is not the whole story. Some prime mover, as a steam engine, must first drive an electric generator and the current must then be conveyed to the motor by wires. The generator efficiency will average 92 per cent and the line transmission 95 per cent. This makes a combined average efficiency for the generator, line and motor of $0.92 \times 0.95 \times 0.75 = 0.65$.

26 Using this value gives $\frac{28.4}{0.65} = 43.6$ h.p. as the average total power consumption.

27 The cost varies with local conditions, but will rarely be less than 3 cents per kilowatt hour, making the power cost for a year of 300 days at 10 hours $= 0.03 \times 43.6 \times 0.746 \times 3000 = \$2930$.

REFERENCES TO TABLE 2

28 The lineshaft and countershaft journal losses in Table 2 are based on a ratio of 1.94 to 1, in accord with Flather's findings of average machine shop conditions as quoted in Kent's pocket Book, 4th edition, p. 965.

REFERENCES TO TABLE 3

29 The loss of 13.2 h.p. on plain bearings in Table 2 is incurred by the lineshaft journals and the countershafts; it is reasonably accurate to apportion

TABLE 2 LINESHAFT DATA AT 200 R.P.M. WITH PLAIN RING-OILING BEARINGS

Shaft diameter $2\frac{1}{16}$ in. safe for 100 h.p. usual catalog rating	COST
Shaft length 100 ft	$65.20
Main drive belt 14 in. by 30 ft	90.62
Main pulley 56 in	26.77
12 hangers, 26 in. drop with ring oiling bearings	81.60
15 double pulleys on lineshaft	37.25
15 sets of belts to drive countershafts	217.71
Total	519.15
Useful power delivered to the machines, as with the motors	28.4 h. p.
Lineshaft and countershaft journal losses	13.2 h. p.
Total	41.6 h. p
Total annual payment for power at $0.03 per kw-hr. and 3000 hours	
$= 0.03 \times 41.6 \times 0.746 \times 3000 =$	$2760.00

TABLE 3 LINESHAFT DATA AT 200 R.P.M. WITH BALL BEARINGS; OTHERWISE AS IN TABLE 2

Shaft	$65.20
Main Belt	90.62
Main pulley	26.77
2 D Hangers, with medium weight ball bearings next to main pulleys	80.34
10 C Hangers, with light weight ball bearings	269.90
15 pulleys on lineshaft	37.25
15 sets of belts to drive countershafts	217.71
	$787.79
Useful power delivered to the machines, as with the motors	28.4 h. p.
Lineshaft and countershaft journal losses	10.9 h. p.
Total	39.3 h. p.
Total annual payment for power at $0.03 per kw-hr. and 3000 hours	
$= 0.03 \times 39.3 \times 0.746 \times 3000 =$	$2600.00

TABLE 4 LINESHAFT DATA AT 600 R.P.M. WITH BALL BEARINGS

Shaft diameter $2\frac{1}{16}$ in. safe for 96 h.p. usual catalog rating.	
Shaft length 100 ft	$ 48.00
Main drive belt 10 in. by 30 ft	64.80
Main pulley 36 in	10.19
2 B hangers 18 in. drop with medium weight ball bearings next to main pulley	34.68
10 B hangers 18 in. drop with light weight ball bearings	150.00
15 double pulleys on lineshaft	19.41
15 sets of belts to drive countershafts	129.52
Total	$456.60
Useful power delivered to the machines as with the motors	28.4 h.p.
Lineshaft and countershaft losses	4.1 h.p.
Total	32.5 h. p.
Total annual payment for power at $0.03 per kw.-hr. and 3000 hours	
$= 0.03 \times 32.5 \times 0.746 \times 3000 =$	$2180.00

this equally between the two. Ball bearings will save, under average conditions if other conditions remained unchanged, about 35 per cent of the lineshaft journal loss. In this case, therefore, taking the 13.2 h.p. from Table 2, 13.2 × 0.35 = 2.3 h. p. This leaves a loss of 13.2− 2.3 = 10.9 h.p., as given in Table 3.

30 The loss could be reduced by another 2.3 h.p. by mounting loose pulleys and countershafts on ball bearings; but as these parts are generally furnished with the machine it is relatively difficult to secure them so mounted. It must be remembered that it is the user and not the builder of the machine who secures the benefits of the ball bearing mounting and it behooves the user to specify accordingly and to insist on compliance.

REFERENCES TO TABLE 4

31 Referring to the useful power delivered to the machines, the total lineshaft load is now only

$$\frac{1\ \frac{15}{16} \times 7110 \times 600}{12 \times 33{,}000} \times 0.0015 = 1 \text{ h.p.}$$

owing to the reduction in weight of the shaft, pulleys and belts and also the reduction in pull of narrower high-speed belts to 7110 lb.

32 The countershaft total load is 5000 lb., speed 400, but the friction is high at about 0.08 as conditions are not as good for the plain journals of the countershafts. This gives a loss of

$$\frac{2\ \frac{7}{16} \times 5000 \times 400 \times 0.08}{12 \times 33{,}000} = 3.1 \text{ h.p.}$$

33 Total loss = 3.1 + 1 = 4.1, as in Table 4.

L. R. Pomeroy. In Par. 3 of his paper, Mr. Robbins states that the alternating-current motor is essentially a constant speed machine. The variable-speed alternating-current motor, possessing series characteristics, is not adapted to general machine tool driving, but it can be used to more or less advantage to perform operations to which a series motor is adapted, such as driving bending rolls, cranes, etc. In a number of tools it is advantageous to vary the speed, to stop, start and reverse quickly in order to facilitate lining up the work, to take a trial cut, to adjust counterbore, etc. After such adjustment the open or synchronous speed can be used for cutting and the tool then becomes, through its working cycle, essentially a constant-speed machine. The additional speed changes, as outlined, are valuable as time savers and are justified from this standpoint, yet it is not necessary to drive with a direct-current motor.

2 The references in Par. 4 and Par. 57 to geared-head machines or tools equipped with mechanical speed variation hardly do justice to these tools, as the speed-changing mechanism in many of them is

as available and handy as if obtained electrically and, therefore, removes the necessity for individual drive for a tool located in a department group. There is no question that, from a commercial viewpoint, the alternating-current motor is preferable for constant speed work, on account of economy of transmission, the ease of obtaining proper voltage for lighting, and the general upkeep of motors. As an example of this latter point, the case of a large manufacturing concern in the middle west is pertinent. The shop is provided with both direct and alternating-current motors, and the cost of upkeep is $2 per month more for the 600 h.p. in direct-current than for the 4000 h.p. in alternating-current.

3 For railroad shop conditions 75 per cent of all requirements can be fully met by constant-speed motors and as the necessary 25 per cent of direct-current motors for the variable speed machines can be obtained by the use of a motor-generator, it would seem that this is the most desirable combination to use. By providing a synchronous motor for driving the motor generator, an excellent opportunity is given to adjust or to increase the power factor, thereby eliminating the low power factor and its consequent disadvantages. The synchronous motor, besides delivering leading current and neutralizing a low power factor, has 70 per cent of its capacity available for mechanical load, and as this part of the load can be utilized to supply the necessary direct-current for variable speed tools, the combination becomes an efficient one. Alternating-current motors are especially economical and advantageous in wood-working shops on account of the presence of dust and flying particles. If direct-current motors are used, the fire hazard necessitates the use of enclosed motors, which are much larger for a given output, on account of the restricted ventilation due to enclosing.

4 As an illustration of the advantage of reckoning with the intermittent duty of a given machine in determining the size of motor to select for a given service, suppose the requirements are 50 h.p. for five minutes, 10 h.p. for ten minutes, the cycle to be repeated every 15 minutes with speed constant. The speed characteristics of the motor require a shunt excitation, i.e., a definite exciting current in the fields regardless of the load on the armature. The average motor load is

$$\begin{aligned} 50 \text{ h.p.} \times \ 5 \text{ min.} &= 250 \text{ h.p. min.} \\ 10 \text{ h.p.} \times 10 \text{ min.} &= 100 \text{ h.p. min.} \\ \text{Total,} & \ 350 \text{ h.p. min.} \end{aligned}$$

$$\text{or,} \ \frac{350}{15} = 23.3 \text{ h.p. average.}$$

5 The average load will not produce the heating that the cycle will, for the reason that the copper loss varies as the square of the current. The root mean square or equivalent heating will be produced by the following:

$$(50)^2 \times 5 \text{ min.} = 12{,}500 \text{ h.p. sq. min.}$$
$$(10)^2 \times 10 \text{ min.} = 1000 \text{ h.p. sq. min.}$$
$$\text{Total, } 13{,}500 \text{ h.p. sq. min.}$$

Dividing this power by 15 minutes gives the average square as 900, which is equal to 30 h.p.

$$\sqrt{\frac{13{,}500}{15}} = 30 \text{ h.p.}$$

This is the root mean square load, or a load which will produce the same heating if applied continuously as would the intermittent work.

6 Group driving, employing relatively short main and countershafting is not an unmixed evil for the reason that the aggregate stored energy of pulleys, due to flywheel action, is advantageous where slotters, shapers, drills, planers, etc., are present, counteracting in a large measure the shaft friction losses. Very often a better load factor is obtained from the group motors than from the aggregate intermittent service of the individual drive motors. The repairs on individual drive motors are heavier than for the same number of group drive motors. As an illustration, a certain shop has the same number of motors as one of 70 per cent greater capacity located in another city, both shops producing the same kind of output. In the former case individual drive is the rule; in the latter group driving prevails. The repairs per unit of output is larger in the former than in the latter.

7 It is also quite necessary to consider the work to be performed by a given tool in a given department, rather than the range of the tool. For example, a 72-in. boring mill has an ultimate range of work from 72 to 3 in., and with various materials a cutting-speed range of 15 to 25 ft. per min. The total speed range therefore becomes

$$\frac{72 \times 25}{3 \times 15} = 40 \text{ to } 1$$

Where the variety of work a tool will perform is the determining factor a wide range of speed quickly obtained is desirable, but under ordinary machine shop conditions, volume of output is the standard governing the selection of a tool, requiring in many cases constant speed.

8 The ideal condition is when the work is so classified and arranged that the machine is practically performing the same work all the time, i.e., duplication of parts. This condition requires the minimum amount of speed manipulation, at least that which is electrically obtained. The more variable speed is sought for, the further we are getting from ideal conditions. This should promote judicious conservatism and careful analysis to make sure of definite reasons for departure from the ideal standard. A careful study of each tool, with reference to the work to be performed, will establish definite ranges of speed, which will be found quite narrow, and which automatically determine the power requirements. The selection of the driving motor would be governed by the foregoing conditions, and might not apply to the same kind of machine in another shop or even in another department of the same shop, where a different output prevailed.

9 Mechanical changes of a simple character, not covering a very wide range but grouped about the zone of work for which the tool is generally intended or selected to perform, giving changes within comparatively narrow limits, provide variations that are useful and advantageous. This avoids the necessity of using motors with large speed ranges and very often admits of the application of a constant-speed motor, where otherwise a variable-speed motor might be required, all of which tends towards economy in first cost and repairs.

10 The results of comparison vary, depending upon whether the tool output is based on performing stunts or ordinary commercial shop operations. In forge shops at steel plants, where no attempt is made to forge close to size and the machine tools are relied on quickly to reduce the forgings to rough-finished sizes, or where motor shafts are rough forged and then finished on machines, the question of high-speed cutting tools and powerful machines is of the greatest importance. But in railroad shops where the companies purchase driving axles, crank pins, piston rods, etc., rough-turned with a flat-nosed tool to within one-eighth or one-sixteenth of an inch of finished dimensions, an entirely different standard necessarily governs the rating of tools, both as to power and speed requirements. For instance, in a list of parts, 23 in number, scheduled for manufacture at the central or main shop of a large railway, the arrangement is such that the minimum amount of machine work has to be performed at the local or division shop where the repairs are to be made. Piston rods are finished except piston and crosshead fits, crank pins are finished complete except for wheel fit, etc., all of which goes to show that a large quantity of work, at least in railroad shops, requires minimum rather than maximum machine tool duty.

11 The heavy type of so-called high-speed lathe is practically built for forging lathe conditions and under these conditions requires high power to drive, but when, as is frequently the case, this same tool is installed in a railway shop where much smaller cuts are the rule, it is not necessary to provide for such great power, as the full capacity of the tool is never utilized.

12 In order to utilize the full power of such a machine, it is necessary to raise the cutting speed in the same proportion as the area of the cut is reduced, but this is not always possible. For example, a $\frac{3}{8}$ in. by $\frac{1}{8}$ in. cut was taken at 38 ft. per min., while with a cut of $\frac{3}{16}$ in. by $\frac{1}{8}$ in. only 52 ft. per min. could be obtained. With one-half the area of the cut, the cutting speed could be increased only one-third, resulting in the removal of only 57 per cent as much metal. If the full capacity of the machine is not possible, why pay the price for a high power motor when a saving in first cost is possible by the selection of a motor more suitable and a better efficiency can be obtained by running the motor more nearly up to its normal capacity? A 10 per cent loss in efficiency on a 15-h.p. motor capitalized at 10 per cent per annum would amount to $750. The same policy carried out among a large number of machines would result in a considerable saving.

13 The formula in Par. 5 of Appendix No. 2 can be simplified and made more workable if stated as

$$\frac{\text{diameter} \times \text{r.p.m.}}{3.82}$$

This affords a very expeditious method of finding by the slide rule the cubic inches of metal removed per minute, which equals diameter $\times$ r.p.m. $\times$ 3.15 depth by feed. Substituting the values given we have $5.5 \times 45 \times 3.15 \times 0.45 \times 0.06 = 21$ cu. in.

GANO DUNN.[1] It is not a question of whether or not we should have electric motor drive in a machine shop, but what kind of drive. If what Mr. Hess said is true, most of us are wrong, yet I think I am within the facts when I say there are very few machine shops built today that are not electrically driven. If we adopted Mr. Hess's methods of equipping a factory, we should have the conditions shown in Fig. 1 of Mr. Riddell's paper. It is obvious that his form of machine shop is obsolete.

2 After all, the cost of power in our plants is not the principal ques-

[1] Vice-President, Crocker-Wheeler Co., Ampere, N. J.

tion. Some years ago I gathered figures which showed that the cost of power in the average machine shop was only about two per cent of the value of its product. That indicates that questions of saving in power are of minor importance.

3 With Mr. Hess's suggestion, where should we come out on the other vital part of the question, the capacity or output? The day of the electric motor in a machine shop is the day of the red-hot chip. It has driven out belts in the same way that it has driven horses from the front of street cars. It is successful, it is practicable, and it is the one thing that fills all our wants, because it gives us all the power we want, where we want it, when we want it, and as we want it.

4 Mr. DeLeeuw's paper and Mr. Robbins' paper are dictionaries of the art of electric driving. In connection with the classic paper of Mr. Taylor, On the Art of Cutting Metals, we now have a reference library to which we can turn for almost any question likely to come up.

5 I do not believe there is any specific rule that can be laid down to guide an engineer in the layout of a machine shop. Each case must be decided on its own basis. My view of how much power it takes to run a particular machine tool is that it depends on who is the superintendent of the shop. The problem is principally one of capacity. The enormous capacity we can put into a tool by means of the electric drive, to say nothing of all the other advantages that have been rehearsed, it seems to me not only settles the question now, but will continue to settle it.

6 In the very early days, when it was hard to get the attention of manufacturers to the subject of the electric drive, we had to use the argument that it saved power. Then there came a time when it was admitted that electric motors were good for ordinary work, but could not drive rolling mills. And now the climax of rolling-mill development is capped when we see a 6000-h.p. induction motor driving the mill at Gary. I feel that we have now closed the first chapter on the art of the electric drive in machine shops.

FRED. L. EBERHARDT, Vice-President of the National Machine Tool Builders Association, gave a summary of the progress made toward the standardization of motors for machine tools by a committee from his association in conference with one appointed by the American Association of Motor Manufacturers. Fifteen points were proposed for discussion by the former committee, of which seven were agreed upon and have since been adopted by the motor manufactures. The remaining eight are still being studied and discussed. The following

quotations from the report of the committee on standardization of motor drives for machine tools to the Rochester convention of the National Machine Tool Builders Association, May 24, 1910, outlines the present situation:

1 *Horse-Powers.* It is thought that the following horse-powers will meet practically all the requirements of electric drives for machine tools: 1, 1½ (for D. C. only), 2, 3, 5, 7½, 10, 15, 20 and 25. Though it was agreed that horse-powers more than 25 and less than 1 are used, it was not thought advisable to embody them at the present in the attempted standardization, but it was held out that they might be embodied some time in the future among the standardized sizes.

2 *Voltage.* It is recommended that for D. C. motors 115 and 230 volts be adopted as standard, and for A. C. motors 110 and 220 volts. There is now a good deal of confusion as to voltages for D. C. motors. The motor manufacturers have reached an agreement among themselves as to these voltages, and the 115 and 230 voltages recommended by them represent the nominal voltage of the system, and not the real voltage at the motor.

3 It is recommended that the horse-power ratings for machine-tool drives be the standard ratings of the American Association of Electric Motor Manufacturers, i.e., (*a*) that motors be given the continuous constant horse-power rating where approximately standard load conditions exist; (*b*) for adjustable-speed motors used for intermittent service the standard two-hour continuous-duty rating be used for ordinary shop conditions and that the name plates of such motors indicate the time as well as horse-power ratings of the motor, and further that the horse-power be figured at the high as well as the low speed for adjustable speed service.

4 *D. C. Motors.* It is the recommendation of the joint committee that constant speed motors, adjustable speed motors with a range of 2 to 1, and adjustable speed motors with a range of 3 to 1, be included in the attempt at standardization. This does not exclude the occasional use of motors with a different speed range, such as 4 to 1, or even more; but it was the opinion of the committee that motors with a higher range of speed than 3 to 1 are not used to a sufficient extent and are not so absolutely necessary for machine-tool construction as to include them among the standardized motors.

5 The following table of speeds is recommended as the standard for adjustable speed D. C. motors:

h.p.	2 : 1	3 : 1
25	900—450	900—300
20	900—450	900—300
15	1200—600	1200—400
10	1200—600	1200—400
7½	1200—600	1200—400
5	1200—600	1200—400
3	1500—750	1500—500
2	1500—750	1500—500
1½	1500—750	1500—500
1	1500—750	1500—500

6 *A. C. Motors.* It is recommended that the following table of polyphase 60-cycle A. C. motors be adopted:

25 h.p.	900 and 600	5 h.p.	1200
20 h.p.	900 and 600	3 h.p.	1200
15 h.p.	900 and 600	2 h.p.	1200
10 h.p.	1200 and 600	1 h.p.	1800 & 1200
7½ h.p.	1200 and 900		

7 For the consideration of the constant-speed A. C. motors, 60 cycles is to be used as the basis.

8 *Shaft Diameter.* It is recommended that the shaft diameter be figured according to the formula $D = C \sqrt{\frac{\text{h. p.}}{S}}$ in which C is a constant to be agreed upon by motor manufacturers, D the diameter, and S the speed; it is further desired that all diameters up to and including one and one-half inches be given in one-eighth of an inch, and all diameters above one and one-half inches be given in one-quarter of an inch.

9 *Length of Shaft.* It is recommended that there shall be a fixed proportion between diameter and length; the constant to be determined by the motor builders. Further, that the shaft be rounded at the end.

10 *Keyways.* It is recommended that keyways be made for square keys and that the key be equal to one-fourth the diameter of the shaft.

11 *Driving Fit.* It is recommended that there be added to the standard dimensions of the shaft 0.0005 in. for every half inch diameter of the shaft or fraction thereof.

12 *Variation.* It is recommended that shafts shall not be under the specified size, but may exceed same by 0.0005.

13 *Height of Centre.* The height of centre to be given in full one-fourth inch, and shall not be less than figured dimension, but may exceed this dimension by one thirty-second.

14 *Clearance Circle.* It is recommended that the clearance circle around the motor shall have a diameter of one-half inch less than twice the centre height.

15 *Base.* All motors to be held down by four bolts. Bolt holes to be drilled one-sixteenth above size of bolt required. Bottom of motor to be planed parallel with the shaft of motor. It is further recommended that the bolt holes be placed in a configuration of constant proportions, preferably in a square, and that the dimensions of this configuration be made a function of the horse-power divided by the speed, and further that all dimensions be given in the nearest higher one-fourth inch. The feet of the motor should extend beyond the body sufficiently to allow for drilling and reaming of dowel pin-hole while motor is in place.

A. L. Deleeuw. Generally speaking, the machine tool builder does not know to what purpose his product will be applied by the consumer. It is true he knows in a general way that a lathe will be used for turning and a drill press for drilling, but he has no knowledge of the methods employed in the shop where his product is to be used, nor whether

his machine will be used for general work or for some special operation. The machine may never be called upon to work up to its maximum capacity and yet it may be called upon to do this all the time. If the machine is to be supplied with a motor, the only safe thing is to attach a motor of sufficient capacity to run the machine all the time up to its maximum output. Even if it is known that the machine will be used for light work by the man who buys it, yet it may some time come into other hands and be used for entirely different purposes. Hence, unless the machine is supplied with a sufficiently large motor, the design may be condemned at some time.

2 It is true in general that machine tools do not operate at their maximum capacity or even at the rated capacity of the attached motor more than one-third to one-fifth of the time, so that in the majority of cases a much smaller motor can be used than would be required if the machine were constantly working at full capacity. However, the machine tool builder has no guarantee that this general rule will apply to his machine. The tendency nowadays is to specialize in the use of machine tools and to subdivide operations in the shop. Whereas a few years ago it was the custom to give a shaft to some lathe hand to be turned and let him finish all operations on this shaft, preferably in one setting, now it is more common practice first to rough a lot of shafts, then finish them in a subsequent operation, and then perhaps grind them for a final finish. Wherever it is possible to do so, these operations are again subdivided.

3 The subdivision of operations, when carried out to its limit, makes operations in the shop extremely simple, requiring no adjustments of feeds or speeds while a lot is run through the machine and calling for only a single tool. Where operations are carried through in this manner it is often possible to make them continuous. By this is meant that the process is so arranged that both machine and man are working all the time, or at least practically so. The vertical milling machine, for instance, in milling flat surfaces, may do so with the use of a rotary table and a multiple fixture mounted on this table whereby it becomes possible for the operator to load and unload one piece while the cutter is acting on another piece. In this case the feed is adjusted to such a rate that the operator has just time enough to load and unload while the cutter passes over one piece. Where the piece is so small that the time for cutting is materially less than for loading, more than one operator may be used on such a machine; where it is much more than for loading, one operator may attend to two or three machines. In all cases the highest attainable economy

is reached when both operators and machines are working all the time and it should be kept in mind that the rate of work should be such that the machine can keep it up without breakdown, and that the tool will not need an excessive amount of regrinding, nor the operator be fatigued by too rapid work.

4 Though the example given above is perhaps the most perfect application of this system of continuous operation and though rotary fixtures cannot always be applied, there are various means by which this same degree of efficiency can be approximated. The table of the milling machine may be given a reciprocating motion, either automatically or by the hand of the operator, at the end of each cutting stroke. In this case two fixtures are used. Again, a single fixture may be used with two loading fixtures which can readily be clamped in the stationary fixture on the table of the milling machine, so that only a very small amount of time is lost between cutting operations. The relative cost of labor and machine burden would determine whether it would be better to slow the feed down so as to give the operator time to load a fixture or whether two operators should be employed for one machine.

5 The same degree of efficiency can often be reached in lathe operations by providing the operator with two mandrels and dogs and shading the cutting operations down to a point where the time of cutting is just slightly longer than the time for removing a piece from one mandrel and loading a new one. Here again two operators may be employed or one operator may run two machines. There are many cases where the time of the cutting operation is considerably longer than the time required for preparing a new piece for the machine. In such cases it may often be found advantageous to divide the cutting operation into two parts so as to have the time for cutting more nearly equal to that for loading. In a similar way, efficiency on the grinding machine can often be reached by grinding in two operations, one rough and the other for finish. Drilling also lends itself in many cases to the application of this plan, especially where gang drills are used.

6 The application of this principle of keeping both machines and operators busy all the time at their maximum efficiency leads to many interesting problems in the machine shop and could be carried very much further than is done at the present time. The application of this system, however, imposes much heavier duty on the machine tool and would not allow, therefore, of applying to such tools motors which have been rated on the assumption that they will not be called upon for more than two hours continuous service.

CARL G. BARTH. The various advantages of motor drives over belt drives have been thoroughly and ably set forth, but I cannot let go unchallenged the claim of closer speed regulation.

2 While speed controllers of motors are frequently arranged to give successive speeds varying nominally by as little as 5 per cent, the variation in speed consequent on a variation in load is so great as to make it practically impossible to tell beforehand what controller point must be used to insure a predetermined cutting speed for a given piece of work, as required by the most advanced shop management of today.

3 As an exponent of such management I have therefore been forced to remain an advocate of belt drives in preference to individual motor drives; for if a belt is properly cared for and not required to transmit an undue amount of power, its speed variation with load variation is only a fraction of that of an individual motor under the same conditions.

4 This does not mean that I never advocate individual motor drives, for frequently the real advantages of such drives are so great as to outweigh entirely the consideration of the greatest constancy of speed. I hope the time is not far away when motors will be built at a reasonable cost that will be so nearly constant in speed at all controller points, regardless of load, that they will possess incontrovertibly all the advantages claimed for motors in the papers before us.

5 In fact, I have recently learned of a company that expects soon to put on the market a line of 3 to 1 adjustable-speed motors with no greater variation then 4 per cent in any part of the entire range of speeds and loads. If these motors actually materialize, a great step will have been taken towards the millenium of the machine shop engineer vitally interested in cutting speeds. But nothing is yet in sight that promises entirely to replace the belt.

JOHN RIDDELL. Ball bearings are undoubtedly very valuable, but nothing has been said about the quantity of belts required to go with lineshafting in an establishment like the General Electric Company. I pointed out in my paper by very conservative figures that had we continued putting in lineshafting, countershafts, hangers and belts, we would use approximately $6\frac{1}{2}$ miles of lineshafting, about $4\frac{3}{4}$ miles of countershafts, 21,225 hangers, and about $80\frac{1}{2}$ miles of belts. These figures were based on 8500 machine tools. We have in addition to this number possibly 2000 other machines, most of which are driven by motors. These would require many additional feet of shafting and

belts, and a great many more hangers or roller bearings. We know from many years experience that the upkeep and attention required by such material is very great.

2 Machine tool builders seem to think that every electric motor is made for some machine tool, whereas less than 3 per cent of the motors turned out by the General Electric Company are used for this purpose. If the tool builders would standardize their tools so that the same motor would do for the same nominal size of lathe, milling machine, or any other machine tool, the results would be more satisfactory. It would be useless for us to undertake to standardize 70,000 or 80,000 motors when only about 2000 of them would be used for machine tools and these widely distributed over many types. It would not pay any concern turning out electric motors to attempt to standardize for machine tools, especially since they are rapidly being changed and developed. Many machine tools are made to double the work today that they did a few years ago, and had motors been standardized then they would have undergone constant changes. I speak from the standpoint of the middleman, being partly an electrician and partly a mechanician, and knowing the difficulties from both sides.

H. A. Hornor.[1] In a plant which requires a number of tools of large size for operating blacksmith, plate, angle, forge, pattern and joiner shops, the machine shop bears a less important relation to the total power consumption. For the operation of this class of tools constant-speed motors with heavy starting torque, capable of withstanding prolonged overloads, are satisfactory, as the work does not require close adjustment of speed. With an ample power supply of alternating current the losses are reasonably low and are due in large part to the variation of the product. Under these circumstances the induction motor can be used with great economy. It is thrown on the line and reversed with a simple knife switch, requiring no starting compensator and permitting quick stopping and reversing. The induction motor, if substantially designed, will withstand all the shocks which severe duties demand and will give little trouble or expense. A 50-h.p. squirrel-cage induction motor has operated a jogging machine for ten years with no other attention than the oiling of the bearings. The plant just mentioned was equipped with induction motors at the time when the individual motor drive was an experi-

[1] New York Shipbuilding Co., Camden, N. J.

ment and it may be conservatively stated that after a decade it has fulfilled every promise which its advocates claimed at its installation.

W. S. Chase.[1] With reference to the statement in Par. 82 of Mr. DeLeeuw's paper that variable-speed motors should always be used with screw machines, our company has had on the market for two years an automatic screw machine, usually driven by a single belt, all the speeds necessary for the production of any part being controlled within the machine beyond the point of application of power. For electric drive it is merely necessary to supply a motor instead of a belt and the motor may be of any type, alternating or direct-current, of any standard make, and of constant speed. We believe that we were the first to adopt this self-contained single drive on the automatic screw machine, although similar machines have recently been placed on the market.

Clarence L. Collens, 2d.[2] I will limit myself exclusively to adjustable speed-direct-current motors and certain phases of their use in manufacturing machine shops, where the variable-speed machine tool plays an important part in the process of manufacture.

2 *Flexibility of Speed Control.* In order to deal with definite figures instead of general statements Table 1 is submitted. This table is intended to give an idea of the average speed adjustments possible with belt-driven tools, or with gear-box-driven tools using constant-speed motors. By belt-driven tools is meant tools having cone pulleys for speed control. Six representative tools are shown, with a total range of spindle speeds or cutting strokes, indicated for each, which I believe not only represents a fair average of the speeds for which such tools are now designed, but also fully covers all the requirements of the class of work for which each is intended. In the case of the lathes, two different ranges are shown, as it is hard to give a single ratio which will fairly represent all makes and classes.

3 Under both the belt-driven tools and the gear-box tools, columns A and B represent, respectively, the minimum and the maximum number of speed changes found in standard tools of the types shown. In each case both the number of changes and the percentage jump in speed at each change are shown, assuming that the speeds are in geometrical progression. The average practice is more nearly repre-

[1] Manager of Sales, National-Acme Mfg. Co., Cleveland, Ohio.

[2] President, Reliance Elec. and Eng. Co., Cleveland, Ohio.

sented by column A than by column B. In some cases the maximum number of speed changes for the belt-driven tools is greater than for the gear-box types, due to the use of countershafts arranged for two and in some cases three speeds.

4 Compare the figures indicated in the table with the results which can be obtained by using adjustable-speed direct-current motors. With the speeds in geometrical progression and a controller having 20 contact points for speed adjustment. The jump in speed between each step for motors with 1:2, 1:3 and 1:4 speed ratios will be 3.7, 6.0

TABLE 1 SPEED CHANGES ON TYPICAL MACHINE TOOLS

	Spindle Speeds or Cutting Strokes Per. Min.		Belt-Driven Cone Pulley Types				Gear-Box Types using Constant Speed Motors			
			A		B		A		B	
	Total Range	Ratio	no.	per cent	no.	per cent	no	per cent	no.	per cent
24 in. Engine Lathe	3.5-350	1:100	10	66.8	24	22.2	8	93.0	12	52.0
24 in. Engine Lathe	10-360	1:36	10	48.9	24	16.9	8	66.8	12	38.5
4 ft. Radial Drills	20-320	1:16	8	48.6	16	20.3	12	28.6	24	12.8
No. 3 Plain Miller	12-360	1:30	12	36.2	18	22.2	8	62.6	18	22.2
42 in. Vertical Boring Mills	2- 60	1:30	10	45.9	20	19.6	10	45.9	15	27.5
24 in. Crank Shaper	6- 96	1:16	8	48.6	8	48.6	8	48.6	10	36.1
24 in. Drill Press	12-300	1:25	8	58.4	8	58.4	8	58.4	16	23.9
Average percentage jump at each speed change				50.5		29.7		57.7		30.4
Average percentage which cutting or peripheral speeds must necessarily be below maximum if each tool is doing a large range of miscellaneous work				25.3		14.9		28.9		15.2

and 7.6 per cent respectively. With the armature-shifting type of adjustable speed-motor there is of course no jump, the speed change being continuous.

5 From this definite comparison it is almost self-evident that there will be many conditions of work under which the use of the adjustable-speed direct-current motor will result in an increase in the productive capacity of the machine tool of at least 5 per cent, and in many cases 10 per cent as compared with any form of group or constant-speed gear-box drive. In many cases the greater accuracy of

speed adjustment will in itself produce such an increase, and when there is added the greater ease and convenience of making the speed change, the probabilities are more than doubled.

6 In large manufacturing machine shops using specialized tools and limiting each tool to practically single operations with very little change in the size and character of the work on each tool, the question of accurate speed adjustment is of lesser and in some cases no importance, but this is not true of the medium-sized or comparatively small plants. In such plants there is not enough work of any one character to justify a specialized tool, and in consequence each tool of the variable-speed variety is called upon to work continuously over a wide and miscellaneous range of work. Does a 5 per cent increase in productive capacity justify for work of this character the use of the individual adjustable-speed motor?

7 In a small or medium-sized manufacturing machine shop, the average maximum power requirements per tool will usually run well under 5 h.p. Taking 30 cents per hour as the average rate of pay and 30 cents per hour as a fair and probably low overhead charge per tool, the total expense per tool per year of 3000 hours amounts to $1800. Using this figure, 1 per cent increase in productive capacity means an annual saving of $18 per tool.

8 Even taking into account the much lower capacity per tool of the group-drive motor, the difference between the cost of any form of group-drive installation and the individual-drive adjustable-speed motor, including the cost of mounting on the tool, will in some cases be as low as $200 per tool and will rarely exceed $350 per tool in a plant of the size under consideration. Assuming 15 per cent as the rate of interest and depreciation, an increase in productive capacity of from 1.7 per cent to 2.9 per cent will capitalize the additional investment, and from 11 to 20 per cent will pay for it in one year.

9 Even assuming that the plant rents power from some central station and is on the outskirts of a city where only alternating current is available, the additional cost of the motor-generator set will run from $30 to $60 per tool, depending on the size of the plant and the number of variable-speed tools. With the 5-h.p. maximum motor capacity per tool, the generator capacity will be about 2 kw. per tool. An increase in productive capacity of from $\frac{1}{4}$ to $\frac{1}{2}$ per cent will capitalize the motor-generator investment and from 2 to 3 per cent will pay for it in one year.

10 The total additional cost of the direct-current motors and generators, even taking the maximum figures given, will thus be capi-

talized by 3½ per cent increase in productive capacity. Five per cent increase in output means a saving equal to practically 25 per cent of the additional cost of the investment, whereas 10 per cent pays for the change in two years.

11 These figures are well within the possibilities of attainment. It is assumed, however, that the plant is crowded for work and is in a position to sell the additional output. This is a fair assumption, as I believe a plant which is not working full capacity would not be apt to consider any change in its power equipment. As Mr. DeLeeuw has said, an increase in the amount of chips per hour is a more vital factor than any relative saving or loss in different methods of transmitting power.

12 *Speed Ratios for Direct-Current Adjustable-Speed Motors.* In Appendix No. 3 of Mr. Robbins' paper, he has in all cases shown 1:3 as the ratio for adjustable-speed direct-current motors. I agree with Mr. Robbins that this will probably become the ultimate standard for many classes of machine tools, but I do not feel that it will ultimately become the standard for all classes, nor does it lend itself entirely to current designs.

13 The choice of the proper speed ratio for an adjustable-speed motor resolves itself into a very careful study of the ratios of the different gear changes for which the tool is arranged. In the case of engine lathes a motor of 1:3 or even 1:2 speed ratio is usually wholly satisfactory, due to the fact that more attention has probably been given to the application of motors to lathes than to any other tool, and in the designs of motor-driven lathes there are always a sufficient number of gear changes so that the jump in speed between gear changes is rarely more than 200 per cent and is therefore completely covered by an adjustable speed motor of 1:3 speed ratio. This also applies to millers, radial drills, boring mills, etc., with double instead of single back gears.

14 There are, however, a large number of tools, including many millers, boring mills, radial drills, drill presses, shapers, etc., which when belt-driven have merely a cone pulley and a single back gear. When an adjustable -speed motor is applied to such a tool, as a rule it merely takes the place of the cone pulley and no change is made in the back-gear ratio, which is seldom less than 1: 4 and is in many cases greater than 1:6. In consequence, there are many tools on which the use of motors with 1:4, 1:5, or 1:6 speed ratios is not only wholly practical but is more economical from an operating standpoint in all cases where accurate speed control is in any way essential. Unless a motor

is used whose range of speeds has the same ratio as the back gear, there will be a jump or gap of more or less greater magnitude right in the center of the entire range of spindle speeds. It seems illogical to provide close speed adjustment over part of the range and not to provide it over all.

15 Take a tool with eight spindle speeds in geometrical progression from 20 to 320 r.p.m., obtained with a four-step cone pulley and a single back gear. Without going into the theory of geometrical series, the ratio from the first to the fifth speed in this series is practically 1:5. This fixes the ratio of the back gear for the cone-pulley type of tool. If a 1:3 motor is used with this same back gear, the speeds obtained are 20 to 60 r.p.m. with the back gear in and 100 to 300 r.p.m. without the back gear, leaving a jump of 67 per cent between the two series. As speeds below 40 r.p.m. and above 200 r.p.m. are probably not used more than 10 per cent of the time, this means an important break in the center of the active range. This jump may not look very serious with a 1:5 back-gear ratio, but in many cases the ratio is 1:6, meaning a jump of 100 per cent.

16 In this same case a 1:5 motor would give speeds from 13 to 64 r.p.m. with the back gear in and from 64 to 320 r.p.m. without, leaving no jump or break in the entire range. A still more satisfactory arrangement would be obtained if the tool manufacturer changed the ratio of his back gear from 1:5 to 1:4 when furnishing his standard tool with motor drive. If this is done, a motor with 1:4 speed ratio is just as satisfactory as the 1:5 motor, gives an unbroken range of spindle speeds, and is less expensive. The range of spindle speeds then becomes 20 to 80 r.p.m. with the back gear and 80 to 320 r.p.m. without.

17 I would not make this criticism if the machine tool manufacturer made a practice of changing the ratio of his back gear when furnishing certain standard belt-driven types of tools equipped for drive by an adjustable-speed motor. There are many tools, with single back gears whose total range of speeds is 1:16 or slightly greater and to which the addition of a second gear change for motor drive would add unwarranted expense. In most cases a change in the ratio of the back gear would add practically no expense, would simply mean a few additional stock gears for the manufacturer, and would make a motor-driven unit which is much more satisfactory to the purchaser. A motor with at least a 1:4 speed ratio should be used on these tools.

18 A motor of at least 1:4 speed ratio is also desirable on any variable-speed tool which, when belt-driven, is provided with no

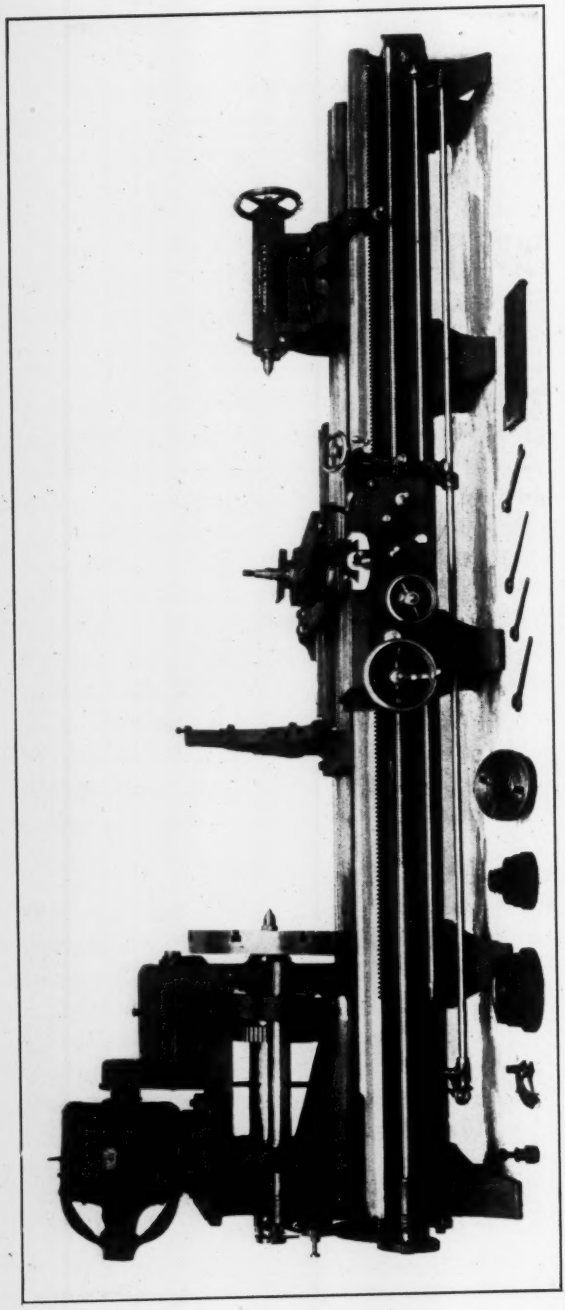

FIG. 1 APPLICATION OF ARMATURE-SHIFTING MOTOR TO A LATHE

back gears. Slotters and some types of bolt machinery come in this class.

19 On certain specialized tools a consecutive range of spindle speeds with graduations not exceeding 5 per cent is not always necessary. Take for instance a driving-wheel lathe, used almost exclusively on two diameters of work, the outer tire and the finished spots

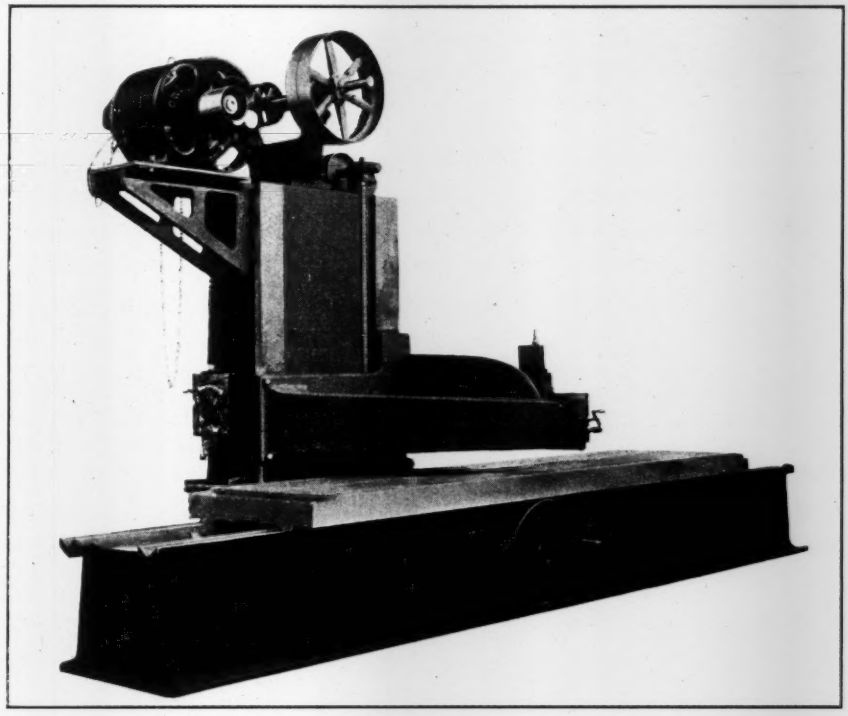

FIG. 2 ARMATURE-SHIFTING MOTOR APPLIED TO A PLANER

on the axle for the bearings. A single back gear, taking into account the difference in the diameter of the axle and tire, as well as the difference in the materials of which these are made, and a motor of 1:2 speed ratio would be wholly satisfactory, even though this left a break of over 200 per cent in the center of the entire range of spindle speeds.

20 *Applying Motors to Old Belt-Driven Tools.* Another field for a motor of at least 1:4 speed ratio is in conversion to motor drive of

old belt-driven tools. The majority of there have merely single back gears and the ratio is rarely less than 1:6. In changing many such tools for motor drive, especially the smaller and medium-sized machines, it is not only simpler but in many cases less expensive to to use a wide-range motor rather than to install additional gear changes.

21 Take for instance the headstock drive shown in Fig. 18 of Mr. Fair's paper. I feel sure that the single back gear in this lathe had a ratio of at least 1:9. If a motor 1:3 were used without additional gear changes there would be a jump of 200 per cent in the center of the entire range of spindle speeds. Mr. Fair prevented this gap in the speeds by using a 1:3 motor with two gear combinations between the motor and the quill which replaced the former cone pulley. The ratio between these two combinations of gear drive was probably 1:3, giving a total range of speeds to the quill of 1:9, so that there was no jump or break between the range of spindle speeds obtained from the quill direct and the range obtained through the back gear.

22 If in such cases a 1:6 motor is used and the ratio of the back gear is changed from 1:9 to 1:6, the drive from motor to the quill can be made direct, either by silent chain or with an intermediate gear, doing away entirely with the change gears, extra shafting and bearings. This gives a total range of spindle speeds of 1:36 without any break, which fully covers most requirements on lathes up to 24 in.

23 It is a very simple and inexpensive matter to change the sizes of two gears on shafts already in place, with bearings and supports already provided. To change the ratio of the back gear from 1:9 to 1:6, it is merely necessary slightly to increase the diameter of the pinion at the back end of the cone pulley or quill, decreasing correspondingly the gear with which it meshes on the back-gear shaft. The additional cost of a 5-h.p. 1: 6 motor as compared with a 5h. p. 1:3 motor will not exceed $75, which I believe is fully offset by the more simple application and mounting.

24 *Choice of Series, Shunt or Compound-Wound Motors.* The only change I would suggest in the table of motors for machine tools given on page 618 of Mr. Fair's paper would be to show shunt motors as well as compound-wound motors under shapers, slotters and reciprocating keyseaters. On these tools the maximum load comes during the cutting stroke, which is usually of sufficient duration to have the load reach a constant value. As the return stroke is of less duration than the cutting stroke, there is no chance to utilize a flywheel effect.

25 *Types of Adjustable-Speed Direct-Current Motors.* There are two distinct types of adjustable-speed direct-current motors used for machine tool work, both operating on the same final principle, namely the increase in speed of a direct-current motor with any decrease in the strength of the magnetic field within which the armature rotates. In one type the strength of the magnetic field is varied by the use of

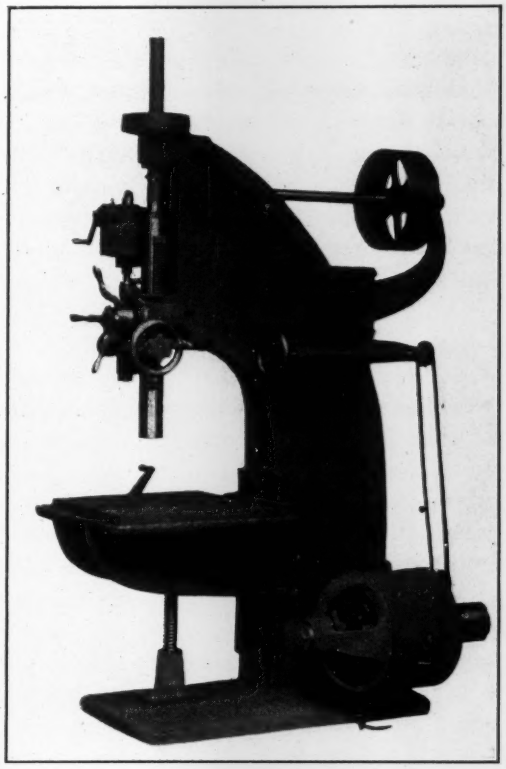

FIG. 3 DRILL PRESS DRIVEN BY AN ARMATURE-SHIFTING MOTOR

resistance in the field circuit, and in the other the magnetic reluctance of the magnetic circuit is changed by sliding a slightly cone-shpaed armature laterally away from its normal position directly beneath the main poles.

26 The characteristics and advantages of the armature-shifting type of motor for machine tool work are briefly as follows:

a No resistance controller is required. The speed control is mechanical, obtained by turning a hand wheel, an operation with which the machinist is thoroughly familiar. This hand wheel can be located at any point convenient to the operator.

b The speed control is a distinct and separate coperation from the starting, stopping or reversing of the motor. Two advantages are derived from this: (1) automatic-type starters can be used, taking entirely away from the machine-tool operator all electrical control of the motor and all possibility of abuse to motors, starting equipment or controllers; (2) when the speed is once set, the motor can be started and stopped as often as is necessary to caliper work or sharpen tools without affecting the speed-setting. In the case of unskilled operators, the speed can be set by a man or speed boss and cannot be tampered with.

c A continuous speed-change is obtained instead of jumping by steps.

d The field distortion due to full-load armature current is practically no greater at high speed under weak magnetic field than at low speed under full magnetic field, due to the fact that under decreasing magnetic field the magneto-motive-force remains constant, the air-gap length is increased and the air-gap area decreased. Satisfactory commutation is therefore obtained over wide speed ranges and is still further augmented for heavy overloads by the use of interpoles.

e Wide speed ranges are secured without excessive cost. These are very often found valuable in applying adjustable-speed motors to machine tools having single back gears, or in converting to motor drive old belt-driven tools.

27 *Methods of Applying Armature-Shifting Motors.* The convenience of speed control with a field-resistance drum-type controller has been well illustrated and is always important from an operating standpoint. Equal convenience can also be obtained in the arrangement of the mechanical speed control of the armature-shifting type of adjustable-speed motor. Fig. 1 shows a 30 in. by 24 ft. engine lathe with the mechanical speed control operated from the crank handle at the right of the lathe apron, the connection to the motor being obtained by means of a splined shaft running along the lathe bed. A second splined shaft operated by a hand wheel, also at the lathe

apron, controls the full-reverse drum-type starter seen on the right at the end of the lathe bed. The two operations are therefore separate but are both controlled from the same point. Fig. 2 shows a satisfactory and convenient method of controll ng the speed where the motor is mounted high on the machine tool. This is done by means of a pendent chain similar to that used on chain hoists. Fig. 3 shows a high-speed drill press with the hand wheel for mechanical speed control brought to a point within easy reach of the operator at all times.

28 *Conclusion.* No one type of drive entirely meets all the varying conditions which are found in machine-tool operations. There are many cases where I would recommend belt drive or speed-box drive with either group or individual constant-speed motors. Other conditions require adjustable-speed direct-current motors with field resistance control, while in many others the mechanical speed-control obtained with the armature-shifting type adjustable-speed motor offers advantages which cannot be obtained with any other method of machine tool drive.

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The twenty-seventh annual convention of the American Institute of Electrical Engineers was held June 28-July 1 in Jefferson, N. H., with headquarters at the Waumbek Hotel.

Among the papers presented were: Disruptive Strength with Transient Voltages, by Joseph L. R. Hayden and Charles P. Steinmetz, Mem. Am. Soc. M. E.; Vector Power in Alternating-Current Circuits, by A. E. Kennelly; Parallel Operation of Three-Phase Generators with their Neutrals Interconnected, by George I. Rhodes; Interaction of Flywheels and Motors When Driving Roll Trains by Induction Motors, by F. G. Gasche; Electric Locomotive Design, by N. W. Storer and G. M. Eaton; A Method of Determining the Adequacy of an Electric Railway System, by R. W. Harris; Power Economy in Electric Railway Operation—Coasting Clock Tests on the Manhattan Elevated Railway, by H. St. Clair Putnam; Economy in Car Operation, by Cyril J. Hopkins.

THE AMERICAN SOCIETY OF CIVIL ENGINEERS

The American Society of Civil Engineers held its 42d annual convention at the Congress Hotel, Chicago, from June 20 to 24, 1910, with a registered attendance of 540. The main object of the summer conventions of the society is to enable members to meet each other socially and discuss informally matters of engineering interest, and no technical papers were read but those in attendance were given an opportunity to become acquainted with engineering works of importance in and near Chicago.

On the evening of June 21, Alfred Noble, Mem. Am. Soc. M. E., Past-President of the American Society of Civil Engineers, described the New York tunnel extension of the Pennsylvania Railroad, illustrating his description with lantern slides. Illustrated addresses were also delivered on succeeding evenings by J. Waldo Smith, Mem. Am. Soc. M. E., chief engineer of the Board of Water Supply of New York, on the new water supply for that city; and by D. H. Burnham, describing the perfected plans for the beautifying of the city of Chicago.

All day trips were made to Gary, Ind., where the new steel plant was visited; to Lockport by boat down to the Drainage Canal; and to Lake Bluff to inspect the new United States Naval Training Station which it is expected will be completed in October. Other short excursions were made to the Chicago and Northwestern Railway terminal now under construction; to the Fish street power station of the Commonwealth Edison Company; and to the mail order house of Sears, Roebuck & Company.

Reports of committees were also presented during the convention.

OPENING OF FRITZ ENGINEERING AND COXE MINING LABORATORIES AT LEHIGH UNIVERSITY

The John Fritz Engineering Laboratory and the Eckley B. Coxe Mining Laboratory were formally dedicated at Lehigh University on June 11, 1910. The gift of the Engineering Laboratory by John Fritz, Hon. Mem. Am. Soc. M. E., was announced at the 1909 meeting of the alumni and by vote of the trustees has been named in honor of its donor, the father of the steel industry in the United States. The Mining Laboratory was named in memory of Eckley B. Coxe, Past-President Am. Soc. M. E., now deceased, a former trustee of the university and its warm friend.

Robert W. Hunt of Chicago, Past-President of the American Institute of Mining Engineers and of The American Society of Mechanical Engineers, a personal friend of both Mr. Fritz and Mr. Coxe, made the speech of dedication. He reviewed in some detail the remarkable engineering progress of John Fritz, commencing with his start as a blacksmith and including the establishment of the Bethlehem Bessemer Works, which introduced the Bessemer process into this country and is the greatest monument to his fame. Nevertheless, he said, although Mr. Fritz has lived to see eventful developments in science, from the construction and operation of steam to the navigation of the air, and in his own particular field of engineering has participated in the development of a revolutionizing process, he is of the present and building for the future in the establishment of this testing laboratory, made after his own design and constructed under his own supervision.

In speaking of Mr. Coxe, Mr. Hunt said: "It was my good fortune to have him as a friend. To know him was to love him. He had been given all the advantages of education and travel. He inherited great wealth and not only wisely administered it, but, in so doing, built up a large business and brought together a thriving community of people whose welfare he regarded and ministered to as a sacred trust. With all his wealth, education, travel and position, he remained as simple-hearted as a boy."

Both Mr. Fritz and Mr. Coxe served Lehigh University on its Board of Trustees and were deeply interested in its welfare. They were moreover intimate and attached friends, and the dedication of the two laboratories on the same day was therefore most appropriate.

INTERNATIONAL HUNTING CONGRESS

The second International Hunting Congress, which will be held in Vienna, Austria, September 5-7, 1910, intends to give an important place in its deliberations to international technical questions regarding weapons used in hunting. A number of entry forms have been furnished the Secretary of the Society, and may be secured on application.

DEDICATION OF FOREST PRODUCTS LABORATORY

The new Forests Products Laboratory established at the University of Wisconsin with the coöperation of the Forest Service of the United States was for-

mally dedicated Saturday, June 4, 1910, in the presence of representatives of lumber manufacturing and woodworking associations from all parts of the country. Chief Forester Henry S. Graves in the principal speech of the occasion outlined the work to be undertaken in investigating the more effective utilization of forest products.

The laboratory was open in the morning to the inspection of visitors, all the apparatus and machinery being in operation. The experiments which will be carried on will be of great importance to all wood users, and will include the department of wood preservation where the effect of different preservatives will be tested; and departments for tests of the strength and other properties of timber, the saving of wood waste by means of distillation processes; and the fibre of various woods for paper and other purposes.

The building in which the work will be carried on has cost about $50,000 and the equipment, most of which has been brought from the small forestry laboratories formerly maintained by the government at various places, is valued at $100,000 more.

The American Society of Mechanical Engineers was represented at the dedication by Carl Albert Johnson and Prof. T. G. D. Mack.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION

The National Society for the Promotion of Industrial Education has submitted to President Taft a report on the Relation of Industrial Training to the General System of Education in the United States. This report takes the need for more industrial life as a self-evident and long-acknowledged fact, and lays particular stress upon the need for a comprehensive and thoroughgoing statistical investigation with reference to the following points: (1) The needs of the different states and localities for skilled persons in the trades; (2) the character of the curricula and the service of existing industrial and apprentice schools in the United States; (3) the relation of existing industrial schools to the general educational system of their state and of their region; (4) the lessons to be learned from industrial schools in foreign countries. The report recommends that the above investigation be entrusted to the United States Department of Education and that the financial support necessary be furnished by Congress.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

The attendance at the eighteenth annual meeting of the Society for the Promotion of Engineering Education, held in Madison, Wis., June 23-26, 1910, was 149, exceeding that of any previous meeting of the organization.

Papers were presented on Inspection Trips for Technical Students, by Prof. George C. Shaad; The Teaching of Judgment, by Edward J. Kunze, Mem. Am. Soc. M. E.; Inspection Trips of Ohio State University Students, by Prof. Wm. T. Magruder, Mem. Am. Soc. M. E.; Recent Progress in Coöperative Technical Education, Herman Schnieder; Clearness and Accuracy in Composition, J. J. Clark; Character Training, J. P. Jackson, Mem. Am. Soc. M. E.; Technical Education in Germany, Frank Koester; Technical Education in China, W. H.

Adams, Mem. Am. Soc. M. E.; and a symposium on Coöperative Work for the Railroad Commission and Tax Commission of Wisconsin, by Prof. W. D. Pence, J. G. D. Mack, Mem. Am. Soc. M. E., and C. P. Burgess. Dr. George H. Shepard, Mem. Am. Soc. M. E., presented a very full and interesting summary of methods used in German technical universities and a comparison with American methods. The Report of the committee on Engineering Degrees was read by the chairman, Prof. W. F. M. Goss, Mem. Am. Soc. M. E., and after much discussion accepted.

The following officers were elected for the year 1910-1911: President, A. N. Talbot; Vice-Presidents, Wm. Kent, Mem. Am. Soc. M. E., and M. S. Ketchum; Treasurer, Wm. H. Wiley, Mem. Am. Soc. M. E.; and Secretary, H. H. Norris.

AMERICAN SOCIETY FOR TESTING MATERIALS

The thirteenth annual meeting of the American Society for Testing Materials, affiliated with the International Association for Testing Materials, was held at the Hotel Traymore, Atlantic City, N. J., June 28-July 2, 1910, with an attendance of 450. Among the reports and papers presented at the business sessions were: Report of Committee on Standard Specifications for Cast-Iron and Finished Castings, Walter Wood, Mem. Am. Soc. M. E., chairman; Tests of Cast-Iron Arbitration Test Bars, C. D. Mathews; Untruly and Unevenly Chilled Car Wheels, T. D. West, Mem. Am. Soc. M. E.; Report of Committee on Standard Methods for Testing, Prof. Gaetano Lanza, Mem. Am. Soc. M. E., chairman; Report of Committee on Standard Specifications for Hard-Drawn Copper Wire, J. A. Capp, Mem. Am. Soc. M. E., chairman; The Forest Products Laboratory, its Purpose and Work, McGarvey Cline; Tests on Steel and Wrought-Iron Beams, H. F. Moore; Report of Committee on Standard Specifications for Steel, William R. Webster, Mem. Am. Soc. M. E., chairman; Elongation and Ductility Tests in Rail Sections under the Manufacturers' Standard Drop-Testing Machine, P. H. Dudley; Cupreo-Nickel Steel, G. H. Clamer; Report of Committee on Standard Specifications for Cement, George F. Swain, Mem. Am. Soc. M. E., chairman; Aluminates: Their Properties and Possibilities in Cement Manufacture, Henry S. Spackman, Mem. Am. Soc. M. E.; Tests on Reinforced Concrete Columns subjected to Repeated and Eccentric Loads, M. O. Withey; Report of Committee on Standard Specifications for Coal, J. A. Holmes, Mem. Am. Soc. M. E., chairman; Fuel Investigations, U. S. Geological Survey; Progress during the year ending June 30, 1910, J. A. Holmes, Mem. Am. Soc. M. E.; Report of Committee on Standard Specifications for Vitrified Clay and Cement Sewer Pipe, Rudolph Hering, Mem. Am. Soc. M. E., chairman; A Comparison of Magnetic Permeaters, Chas. W. Burrows.

On Wednesday evening, June 29, a session was held in honor of the memory of Dr. Charles B. Dudley, Mem. Am. Soc. M. E., late president of the society and of the International Association for Testing Materials. The various phases of Dr. Dudley's life and life-work were treated by Theodore N. Ely, Mem. Am. Soc. M. E., Prof. Edgar F. Smith, Prof. Henry M. Howe, Lieut.-Col. B. W. Dunn, W. H. Schwartz, and Robert W. Hunt, Mem. Am. Soc. M. E.

The following officers were elected: President, Prof. Henry M. Howe of New York; Secretary and Treasurer, Prof. Edgar Marburg; Vice-President, Robert W. Lesley; Member of Executive Committee, James Christie, Mem. Am. Soc. M. E.

OHIO ELECTRIC LIGHT ASSOCIATION

At the 16th annual convention of the Ohio Electric Light Association held from July 26-28 at Cedar Point, O., papers were presented on Turbine Troubles by Frank Brosius; Outline of an Equitable Power Rate, B. H. Gardner; Central Station Facts and Factors, J. R. Cravath; Motors for Single-Phase Circuits as They Are Today, Prof. F. C. Caldwell; Low-Pressure Turbines and their Operation, W. C. Anderson.

CANADIAN ELECTRICAL ASSOCIATION

The twentieth annual convention of the Canadian Electrical Association was held July 6-8, 1910, at Lake Rosseau, Ontario, Canada, with the Royal Muskoka Hotel as its headquarters.

Among the papers presented were: Protection of Service in Large Electric Systems, A. S. Loiseaux; Notes on Transmission Line Regulation, Paul M. Lincoln, Mem. Am. Soc. M. E.; Tungsten Street Lighting with Special Reference to 25-cycle Circuits, C. L. Stephens; The Diesel Oil Engine, F. A. Yerbury.

A number of special committee reports were presented, including those of the committees on standardization of line construction, grounding of transformer secondaries, installation, care and testing of meters, conservation of natural resources.

AMERICAN CHEMICAL SOCIETY

The American Chemical Society at its annual convention in San Francisco, Cal., from July 12-16, 1910, held a general session of its membership on July 13, followed by divisional sessions on the succeeding days. Among the papers presented before the division of agriculture and food chemistry was that on the Extent and Composition of the Incrustation on Filter Sands, by Edward Bartow and C. E. Millar. A symposium on smelter smoke was given before the division of industrial chemists and chemical engineers, including Neutralization and Filtration of Smelter Smoke, by W. C. Ebaugh; The Smoke Problem and the Community, by Charles Baskerville.

NATIONAL CONSERVATION CONGRESS

The second National Conservation Congress will be held at St. Paul, Minn., September 6-9, 1910. The objects of the Congress are (1) To provide for discussion of the resources of the United States as the foundation for the prosperity of the people; (2) To furnish definite information concerning the resources and their development, use and preservation; (3) To afford an agency through which the people of the country may frame policies and principles affecting the conservation and utilization of their resources to be put into effect by their representatives in state and federal government.

PERSONALS

Charles Whiting Baker served as a delegate from the United States appointed by the State Department at the International Congress of Mining, Metalurgy and Applied Mechanics at Düsseldorf, June 1910.

John C. Bertsch has been appointed a delegate by the United States to the Second International Congress of Refrigerating Industries at Vienna, to be held next October.

Prof. L. P. Breckenridge of the department of mechanical engineering at Sheffield Scientific School, Yale University, received the honorary degree of Doctor of Engineering at the commencement of the University of Illinois. Professor Breckenridge was formerly a member of the faculty at the latter university.

H. M. Byllesby has been elected a director of the Chicago, Milwaukee, Puget Sound R. R.

N. A. Carle has opened an office in the Central Building, Seattle, Wash., for practice as consulting and contracting engineer in mechanical, electrical and mining work.

Geo. W. Clancy, formerly general shop inspector of the New Haven System, Readville, Mass., has become president of the Globe Chemical Co., Boston, Mass.

Frank S. Clark has been transferred from the Cincinnati Traction Co. to the Ohio Electric Railway Co., as assistant engineer, with headquarters in Springfield, O.

W. L. R. Emmet received the degree of Doctor of Science from Union University at its recent commencement.

J. H. Fox, of Frazier & Fox, Cleveland, Ohio, has accepted an appointment as chief engineer of the Pittsburg Plate Glass Co., Pittsburg, Pa.

Howard D. Hess, formerly assistant professor of machine design at Cornell University, Ithaca, N. Y., has been made professor of machine design.

Thomas H. Mirkil, Jr., has resigned as general manager of the Southward Foundry & Machine Co., Philadelphia, Pa., to accept a similar position with the Poole Engineering and Machine Co., Baltimore, Md.

V. M. Palmer, chief engineer of the Selden Motor Vehicle Co., Rochester, N. Y., has resigned his position to accept a similar position with the Sheldon Axle Co., Wilkes Barre, Pa.

William E. Smith, formerly a draftsman with the Babcock & Wilcox Co., Barberton, O., now holds a similar position with the Browning Engineering Co., Cleveland, O.

Wm. S. Twining has resigned as chief engineer of the Philadelphia Rapid Transit Co., to become associated with Ford, Bacon & Davis, New York.

H. H. Westinghouse, has been elected president of Westinghouse, Church, Kerr & Co., New York.

On June 1, Columbia University conferred the degree of Doctor of Science on Sir William Henry White, Hon. Mem. Am. Soc. M. E.

CURRENT BOOKS

THE ELEMENTS OF REINFORCED CONCRETE BUILDING. By G. A. T. Middleton. *New York, Spon & Chamberlain, 1910.* Cloth, 8vo, 111 pp., illustrated. Price, $1.50.

Contents: Rectangular Beams with Supported Ends; Bending Moments—Resistance Moments—Designing from given data; Vertica; Reinforcements; T-and L-Beams with Supported Ends; Continuous Beams; Beams with Double Reinforcement; Floor Slabs; Foundations; Columns; Walls and Retaining Walls; Materials; Mixing and Laying the Concrete—Falsework, or Centering—Connections; Some Patent Systems.

METROPOLITAN WATER AND SEWERAGE BOARD, 9th Annual Report, 1909. *Boston, Wright & Potter Printing Co., 1910.* Cloth, 8vo, 272 pp., illustrations and maps.

Contents: Organization and Administration; Metropolitan Water District; Metropolitan Water Works—Construction; The Construction of the Metropolitan Water Works from 1895 to 1910; Water Works—Maintenance; Water Works—Financial Statement; Metropolitan Sewerage Works; Sewerage Works—Financial Statement; Consumption of Water; Electrolysis; Recommendation for Legislation; Future Work.

RAILROAD STRUCTURES AND ESTIMATES. By J. W. Orrock. 1st edition. *New York, John Wiley & Sons, 1909.* Cloth, 8vo, 270 pp., illustrated. Price, $3.

Contents: Track Material; Fences, Gates, Sign Posts, Road Crossings and Guards; Culverts; Bridges; Buildings; Water Stations; Shops; Specifications and Contracts; Estimating Notes.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure and E. R. Maurer. 2d edition, revised and enlarged. *New York, John Wiley & Sons, 1909.* Cloth, 8vo, 429 pp., illustrated. Price, $3.50.

Contents: Introductory; Properties of the Material; General Theory; Tests of Beams and Columns; Working Stresses and General Construction Details; Formulas, Diagrams and Tables; Building Construction; Arches; Retaining Walls and Dams; Miscellaneous Structures; Re-inforced Concrete Chimneys.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured request from Calvin W. Rice, Secretary, Am.Soc.M.E.

AMERICAN CERAMIC SOCIETY. Transactions. Vol. 1–2. *Columbus, O., 1900* Gift of the society.

AMERICAN RAILWAY ASSOCIATION. Proceedings of special session held in New York City, January 27, 1910. *New York, 1910.* Gift of the association.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS. Transactions. Vol. 2, No. 2. *Madison, 1908.* Gift of the society.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Proceedings. Vol. 28, No. 1–4. *New York, 1906.*

ANNUAIRE DE LA JEUNESSE. 1909. By H. Vuibert. *Paris, 1909.* Gift of Société des Ingenieurs Civil de France.

CENTRAL RAILWAY CLUB. Proceedings. April 1894, September 1896, November 1901, January 1902, January and September 1906. *New York, 1894, 1896, 1901, 1902, 1906.*

CITY AND GUILDS OF LONDON INSTITUTE. Programme of the City and Guilds Central Technical College. June 1910. *London, 1910.* Gift of institute.

CLINKERS AND THE FUSING TEMPERATURE OF COAL ASH. By E. G. Bailey. *1910.*

COMMISSION PERMANENTE INTERNATIONALE D'AERONAUTIQUE. Procès verbaux et comptes rendus des travaux de la session extraordinaire, tenue à Bruxelles, Sept. 12-15, 1907. *Paris, Dunod et Pinat, 1908.*

ELECTRIC TRACTION ON CITY AND SUBURBAN RAILWAYS. By H. M. Hobart. Gift of C. W. Rice.

ELEMENTS OF REINFORCED CONCRETE BUILDING. By G. A. T. Middleton. *New York, Spon & Chamberlain, 1910.*

HOW TO SAMPLE COAL AND COKE. By E. G. Bailey. *1910.*

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. Twenty-fifth Annual Report. 1910. *Chicago, 1910.* Gift of the society.

LELAND STANFORD JUNIOR UNIVERSITY. Register 1909-1910. *San Francisco.* Gift of the university.

LOW GRADE PORPHYRY COPPER MINES. *1910.*

MASSACHUSETTS WATER COMMISSIONERS. Thirty-sixth Annual Report. 1909. *Springfield, 1910.* Gift of the Board.

METALLOGRAPHIE. By W. Guertler. Vol. 1, Pt. 3. *Gebrüder Borntraeger, Berlin, 1910.*

METROPOLITAN WATER AND SEWERAGE BOARD. Ninth Annual Report. 1910. *Boston, 1910.* Gift of the board.

MILWAUKEE SMOKE INSPECTOR. *Annual Report.* 1909. *Milwaukee, 1909.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. List of Members. 1909. *New York, 1910.* Gift of Municipal Engineers.

NEW ENGLAND RAILROAD CLUB. Proceedings. Jan. 11, Feb. 8, March 8, April 12, May 10, Oct. 11, Nov. 8, Dec. 13, 1898; Jan. 10, Oct. 10, 1899; Jan. 9, Feb. 13, March 13, April 10, May 8, Oct. 9, Nov. 13, Dec. 11, 1900; Jan. 14, March 12, Nov. 11, 1902; March 10, Nov. 10, 1903; Jan. 12, Feb. 9, March 8, April 12, May 10, 1904. *Boston, 1898-1900, 1902-1904.*

NEW YORK CITY BOARD OF EDUCATION. Annual Financial and Statistical Report of the Transactions of the Board. 1906-1908. *New York, 1909.* Gift of the Board of Education.

NEW YORK RAILROAD CLUB. Proceedings. Feb. 15, 1894, and Jan. 17 and March 21, 1895. *New York, 1894-1895.*

PENNSYLVANIA WATER SUPPLY COMMISSION. Annual Report. 1908. *Harrisburg, 1910.* Gift of the commission.

PRINCIPLES OF REINFORCED CONCRETE CONSTRUCTION. By F. E. Turneaure and E. R. Maurer. *New York, J. Wiley & Sons, 1909.*

QUATRIÈME CONGRÈS INTERNATIONAL D'AERONAUTIQUE, NANCY, Sept. 18-23, 1909. Procès Verbaux, Rapports and Mémoires. *Paris, 1909.*

RAILROAD HERALD. Vol. 12, 1907-1908. *Atlanta, 1907-1908.*

RAILWAY STATISTICS OF THE UNITED STATES OF AMERICA. 1909. *Chicago, 1910.* Gift of Slason Thompson.

RAILROAD STRUCTURES AND ESTIMATES. By J. W. Orrock. *New York, J. Wiley & Sons, 1909.*

REINFORCED CONCRETE POCKET BOOK. By L. J. Mensch. *San Francisco, 1909.* Gift of author.

RICHMOND RAILROAD CLUB. Proceedings. Vol. 1, No. 1-7; Vol. 2, No. 3-7 and 9; Vol. 3, No. 1-9. *Richmond, 1902-1904.*

SOUTHERN AND SOUTHWESTERN RAILWAY CLUB. Constitution and Proceedings. Nov. 16, 1893; Jan. 18, April 19, Aug. 16, Nov. 15, 1894; Jan. 17, April 18, Aug. 15, 1895; Jan. 16, April 16, Aug. 20, Nov. 19, 1896; Jan. 21, April 8, 1897; Vol. 5, No. 1-8, 1900-1901. *Atlanta, 1893-1897, 1900, 1901.*

STANDARD SPECIFICATIONS FOR CREOSOTED WOOD BLOCK PAVEMENT. Gift of J. W. Howard.

STEAM TURBINES. By Wilhelm Gentsch. Translated from the German by A. R. Liddell. *New York, Longmans, Green & Co., 1906.*

TRAVELING ENGINEERS' ASSOCIATION. Proceedings of Annual Convention. 1907, 1908. *Buffalo, 1907-1908.*

EXCHANGES

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AMERICAN SOCIETY OF CIVIL ENGINEERS. Transactions. Vol. 67, 1910. *New York, 1910.*

BLOCK SIGNALS ON THE RAILROADS OF THE UNITED STATES. Jan. 1, 1910. *Washington, 1910.*

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CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members. 1910. *Montreal, 1910.*

—Report of Annual Meeting. Vol. 24, 1910. *Montreal, 1910.*

New England Water Works Association. Constitution and List of Members. May 1910. *Boston, 1910.*

Society of Naval Architects and Marine Engineers. Transactions. Vol. 17, 1909. *New York, 1909.*

Technograph. Vol. 24, 1910. *Champaign, Univ. of Illinois, 1910.*

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American Blower Co., *Detroit, Mich.* Bull. No. 267. Detroit steam traps and return trap system, 32 pp.; Bull. No. 273. A B C Hot-Air Heater, 18 pp.

American Electrical Works, *Phillipsdale, R. I.* Price list of wires and cables for electric work, 10 pp.

Contractors Supply and Equipment Co., *Denver, Colo.* Catalogue of contractors' supplies, construction machinery, and repair castings for machines, 44 pp.

Hans Renold, Ltd., *Manchester, Eng.* Driving chains for power transmission, 130 pp.

Hess-Bright Mfg. Co., *Philadelphia, Pa.* Ball bearings and their correct use, 1 p.

Internationale Rotations—Maschinen Gesellschaft, *Berlin, Germany.* Universal rotary engines, 101 pp.

Kieley & Mueller, *New York City.* 1910 catalogue of steam, water, and air specialties, 100 pp.

Link-Belt Co., *Philadelphia, Pa.* Conveying machinery for coal mines, 42 pp.

David Lupton's Sons Co., *Philadelphia, Pa.* Steel sashes and skylights, hollow metal windows, continuous sashes, etc., 52 pp.

National Electric Lamp Assoc., *Cleveland, O.* Bull. No. 11. Operation, manufacture and efficiency of Mazda street service lamps, 11 pp.

Niederrheinisches Eisenwerk, *Dülken, Germany.* Suction cleaning apparatus, 7 pp.

Penton Publ. Co., *Cleveland, O.* Penton's List, May 1910, 8 pp.

Wm. Powell Co., *Cincinnati, O.* Catalogue No. 9. Brass steam and water supplies, valves, gauges, oiling devices, lubricators, etc., 281 pp.

Providence Engineering Works., *Providence, R. I.* Rice and Sargent Corliss engines, 55 pp.

Joseph T. Ryerson & Son, *Chicago, Ill.* Monthly stock list of machinery, iron and steel supplies, May and June 1910, 144 pp. each.

Sprague Electric Co., *New York City.* Catalogue No. 321. Electric fans, 35 pp.

Underfeed Stoker Co. of America, *Chicago, Ill.* Publicity Magazine, May and June, 1910, 15 pp. each.

Villinger Mfg. Co., *Williamsport, Pa.* 14 in. friction drill with quick change speed, 3 pp.

W. Douglas Wooley, *St. Louis, Mo.* C.—C. non-gap lightning arresters, 4 pp.

UNITED ENGINEERING SOCIETY

ANNALEN DER HYDROGRAPHIE UND MARITIMEN METEOROLOGIE. Year 38-date. *Berlin, 1910-date.*

CYCLOPEDIA OF AUTOMOBILE ENGINEERING. Vol. 1-4. *Chicago, 1910.*

JOURNAL FÜR GASBELEUCHTUNG. General Register zum jahrgang 32-46 (1889-1903). *München, 1905.*

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NEVADA STATE CONTROLLER. Annual Report. 1905-1909. *Carson City, 1906-1910.* Gift of Nevada State Controller.

OHIO RAILROAD COMMISSION. Fourth Report. *Springfield, 1910.* Gift of the commission.

POOR'S MANUAL OF INDUSTRIALS, 1910. *New York, Poor's Railroad Manual Co., 1910.*

PRACTICAL INSTRUCTIONS RELATING TO THE CONSTRUCTION AND USE OF THE STEAM ENGINE INDICATOR. *Boston, Crosby Steam Gage & Valve Company, 1910.* Gift of Alfred B. Carhart.

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GIFT OF THE AMERICAN GAS INSTITUTE

American Gas Light Journal. Vol. 56-67. *New York, 1892-1897.*

Association of Gas Engineers and Managers, United Kingdom. Report of Proceedings. 1887-1897. *London, 1888-1898.*

British Associations of Gas Managers. Report of Proceedings. 1876-1879. (Title changed to Gas Institute in 1881.)

Congrès International de l'Industrie de Gaz. Compte rendu des Travaux. Publiè par les Soins de la Société Technique de l'Industrie de Gazen France. 15th-28th, 30th-36th Congress. Paris, 1888-1901, 1903-1909.

——Assemblée Générale Rapports Annexes. *Paris, 1900.*

Deutscher Verein von Gas und Wasserfachmännern. Verhandlungen. 1903-1907. *München, 1903-1907.*

Gas Institute. Transactions. 1884, 1885. *London, 1884-85.*
(Early title to 1881, British Association of Gas Managers.)

Incorporated Gas Institute. Transactions. 1896, 1897, 1899, 1900. *London, 1896-97, 1899-1900.*
(Merged in 1902 to form Institution of Gas Engineers.)

Incorporated Institution of Gas Engineers. Transactions. Vol. 1-6, 8-12. London, 1892-1903.
(Merged with Gas Institute in 1902 to form Institution of Gas Engineers.)

Institution of Gas Engineers. Transactions. 1903-1908. *London, 1903-1908.*

Progressive Age. Vol. 9-14 (6 vol. in three). *New York, 1891-1896.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

039 Young technical graduate in mechanical engineering for designing department of steam engine manufacturers. More especially on the Corliss type. Man with one to three years experience preferred. Excellent chance of advancement if aptitude and initiative are shown.

040 Large eastern manufacturing company wants a mechanical engineering graduate of not less than five years' experience in similar work to act as assistant engineer in the design, estimating and construction of electric power generating plants and general construction engineering. Salary, about $2000, depending on the man.

041 Civil engineering graduate of not less than five years experience to act as assistant engineer in the design of electric power plants and general construction engineering, for large eastern manufacturing company. Should have had experience in foundation work, structural steel, reinforced concrete and general building design and estimating therefor. Must be willing to do work partly of a mechanical or electrical engineering nature, according to his ability and as occasion requires. Salary, about $1500 depending on the man.

042 Master mechanic wanted for stationery manufacturing plant in Massachusetts. Man 30 to 35 years of age with technical education, preferred. Would have charge of power, construction, repairs and general oversight of buildings. Salary, $1500 per year.

MEN AVAILABLE

95 Member, 40 years of age, graduate, chief engineer, originator, designer of gas engines (any size), gas producers (any fuel), gas furnaces (any purpose). American citizen, engineer of construction in large European steelworks, desires to return into suitable position; perfect in English, French and German.

96 Mechanical and structural engineer, fifteen years experience designing machinery, furnace, rolling mill plants and buildings. Technical education. Desires position as chief draftsman or chief engineer.

97 Junior member, graduate Cornell, several years experience technical journalism, experimental and efficiency engineering, desires change. Familiar with open hearth and rolling mill work and general machine shop practice. Desires position in which ability and energy will be recognized and will lead to high-class executive position.

98 Technical and manual training school graduate, age 34, good experience in drafting, estimating, practical machine shop work and testing, desires position preferably in Pennsylvania.

99 Seven years varied engineering experience and six years in selling end. Would consider position where knowledge of machinery and mill supply trade of the United States and Canada is essential. Experience in correspondence and proper design of selling contracts.

100 Cost reduction and production expert; results of last two years work giving an annual net saving of $50,000 open to proposition from reliable parties. Competent and experienced executive.

101 Engineer executive desires to correspond with concern offering field for general engineering and assistant in general office. Salary, minimum $2400.

102 Mechanical engineer, eleven years practical experience, six years in automobile and commercial vehicle business desires high grade shop or executive position. Competent to manage small shop, or would connect with large firm as assistant superintendent or assistant manager. Experience covers drafting room, shop, office, advertising, publicity, and executive duties. Salary $3000.

103 Eastern member, experience as civil and mechanical engineer, designing construction, selling, installation and operation departments of modern power equipment and manufacturing plants; wide personal acquaintance United States, Canada, Great Britain and the continent; successful in dealing with U. S. and foreign government engineer departments, municipal and other public works; familiar with modern office, shop organization and costs; drafting specifications and contracts; good correspondent and executive; active, energetic and resourceful.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALSBERG, Julius (Junior, 1905), Asst. to John Bogart, Const. Engr., 141 Broadway, and 56 W. 95th St., New York, N. Y.

BASFORD, Geo. M. (1889: 1891), Manager, 1905–1909; Asst. to Pres., Am. Loco. Co., 30 Church St., New York, and 134 Primrose Ave., Mt. Vernon, N. Y.

BAXTER, Burke Morgan (Junior, 1908), 1799 Wilton Rd., Cleveland, and *for mail*, Middletown, O.

BENCH, Alfred Rittscher (Junior, 1907), W. H. Zimmerman Co., 903 First Natl. Bank Bldg., Chicago, Ill.

BERTSCH, John Charles (1901), Cons. Engr., 611 Lamar St., Fort Worth, Texas.

BLAKE, Edwin Mortimer (1907), Rm. 1406, 1 Liberty St., New York, N. Y.

BORNHOLT, Oscar Charles (Junior, 1904), Mech. Engr., Ford Motor Co., Piquette Ave. and Beaubien St., Detroit, Mich.

CAMERON, Barton H. (1903), Pres., Cameron Stove Co., and *for mail*, 116 N. Morris St., Richmond, Va.

CHAMBERLAIN, Harry M. (1907), N. Y. C. & H. R. R. R., and *for mail*, Park Chambers, Springfield, Mass.

CLANCY, Geo. W. (Associate, 1909), Pres., Globe Chemical Co., 68 Devonshire St., Boston, and *for mail*, 172 Harvard St., Brookline, Mass.

CLARK, Frank S. (Associate, 1909), Asst. Engr., Ohio Elec. Ry. Co., Springfield, and *for mail*, 132 Bellevue Apts., Dayton, O.

DAVIS, George H. (Junior, 1907), Designer, Inspr., Pub. Wks. Office, Brooklyn Navy Yard, and *for mail*, 608 E. 26th St., Brooklyn, N. Y.

DILLARD, James B. (1907; Associate, 1909), Capt. Ordnance Dept., U. S. A., War Dept., Ft. Adams, Newport, R. I.

DIXON, Charles F. (Junior, 1903), Engrg. Dept., New England Engrg. Co., 50 Church St., New York, N. Y.

DOUD, Arthur T. (Junior, 1907), care Genl. Delivery, Jackson, Mich.

FEICHT, Edward R. (Junior, 1907), Ch. Engr., Sacramento Valley Sugar Co., Hamilton City, Cal.

FIRTH, William Edgar (1893), Mech. Engr., Midvale Steel Co., Box 1606, and 400 W. Chelten Ave., Germantown, Philadelphia Pa.

FORGY, J. Edmonds (Junior, 1906), Charles Warner Co., Du Pont Bldg., Wilmington, Del.

FOSTER, Horatio A. (1895), 332 Oliver Bldg., Pittsburg, Pa.

FOX, John Herbert (1904), Ch. Engr., Pittsburg Plate Glass Co., Frick Bldg., Pittsburg, Pa.

GARLAND, Claude Mallory (Associate, 1906), Mech. Engr., Camden Iron Wks., Camden, and *for mail*, 102 Linden Ave., Collingswood, N. J.

GREEN, John Stevenson (Junior, 1909), 168 Gay St., Manayunk, Philadelphia, Pa.

HALL, Frederick Bellows (1905), Mech. Engr., W. E. Baker & Co., 105 W. 40th St., and 40 Morningside Ave., New York, N. Y.

HANSON, Augustus (1886), 1085 14th St., San Francisco, Cal.

HERBERT, Jack Stanley (1908), Pres., Herbert Engrg. Co., Fleming Bldg., Easton, Pa.

HIGDON, John C. (Associate, 1901), Mech. Engr., Atty.-at-Law and Pat. Solicitor, 605 Missouri Trust Bldg., St. Louis, Mo.

HILLYER, George, Jr., (1898; Associate , 1904), Mgr., Broad River Granite Co., and *for mail*, 5 Crew St., Atlanta, Ga.

IDELL, Percy C. (1901; 1909), Mech. Engr., Sales Dept., Babcock & Wilcox Co., 85 Liberty St., New York, and *for mail*, 157 83rd St., Brooklyn, N. Y.

JACOBI, Albert W. (1885), 286 S. Sixth St., Newark, N. J.

JUNGHANS, Edward K. (1908), care Hendricks & Class, 30 Church St., New York, N. Y.

KEELY, Royal R. (1901; 1907), 360 W. 123rd St., New York, N. Y.

KING, Roy S. (Junior, 1904), Gary, Ind.

LAFORE, John Armand (1904) Sales Mgr., D'Olier Engrg. Co., 121 S. 11th St., Philadelphia, Pa.

LAND, Frank (1900), Secy. and Treas., Land-Wharton Co., 912 Pa. Bldg., Philadelphia, and *for mail*, P. O. Box 145, Berkeley Rd., Merion Sta., Pa.

LATON, Thomas J. (Junior, 1908), Instr. in Drawing and Mech. Engrg., N. H. College, Durham, and *for mail*, Box 14, Madbury, N. H.

McCOLL, J. R. (1903), Member of Firm, Ammerman, McColl & Anderson, 1330–1332 Penobscot Bldg., and 545 John R. St., Detroit, Mich.

McMULLEN, V. E. (Associate, 1907), Genl. Foreman, Gas Eng. Dept., Fairbanks, Morse Mfg. Co., and *for mail*, 1251 Josephine Ave., Beloit, Wis.

MEYER, C. Louis (Junior, 1909), care of Engrg. Dept., Trussed Concrete Steel Co., Detroit, Mich.

NICKEL, Franz F. (1899), 27 Winans St., East Orange, N. J.

PALMER, Virgil Maro (Junior, 1905), Ch. Engr., Sheldon Axle Co., Wilkes-Barre, Pa.

PARSONS, Willard P. (1884), 30 Saratoga Ave., Cohoes, N. Y.

PEDDLE, John Bailey (1909), Prof. Mch. Design, Rose Poly. Inst., Terre Haute, Ind., and *for mail*, R. R. 3, Boyne City, Mich.

PEEK, George Meredith (1892;1900), 562 Bartmer Ave., St. Louis, Mo.

PHARR, Eugene A. (1908), Sugar Planter and Mfr., Morgan City, La.

RIDDLE, Howard Sterling (1905), 433 King Ave., Columbus, O.

SCHLATTER, Rudolf (1901), care Sulzer Bros., Pahnhof, Winterthur, Switzerland.

SCHWARTZ, Carl (1906), Engr., Power Stations, N. Y. C. &. H. R. R. R. Co., Grand Central Sta., Rm. 1231, New York, and 9 Siwanoy Ave., New Rochelle, N. Y.

SHRIVER, Harry T. (Junior, 1893), Prop., T. Shriver & Co., Harrison, and *for mail*, Llewellyn Park, West Orange, N. J.

SMITH, Augustus (1902), Constr., Ft. W. Fifth St., Bayonne, N. J.

SMITH, William E. (Junior, 1908), Draftsman, Browning Engrg. Co., and *for mail*, 11212 Ashbury Ave., Cleveland, O.

STEVENS, Robt. H. (Junior, 1903), Stevens Bros., Engrs. and Contrs., 149 Broadway, New York, N. Y.

STREETER, Robert Leroy (Associate, 1907), Asst. Prof. Mech. Engrg., Rensselaer Poly. Inst., Troy, N. Y.

SYMINGTON, E. Harrison (Associate, 1903), T. H. Symington Co., 616 Ry. Exch., Chicago, Ill.

VANDEMOER, John (Associate, 1904), Cia Metalurgica Nacional, Matehuala, S. L. P., Mexico.

WELLS, J. Barnard (Junior, 1909), Draftsman, A. T. & S. F. Ry., San Bernardino, and *for mail*, 1544 Pleasant Ave., Los Angeles, Cal.

WETMORE, Charles P. (1901), Pres., Am. Adding Mch. Co., and *for mail* Rm. 39, 427 Randolph St., Chicago, Ill.

WHITE, Maunsel (1882), Life Member; Cons. Engr. and Steel Met., P. O. Box 741, New Orleans, La.

WHYTE, Frederic M. (1902), Vice-President, 1908–1910: Genl. Mgr., New York Air Brake Co., Watertown, and *for mail*, 14 Benedict Ave., Tarrytown, N. Y.

WILLIAMSON, Leroy A. (Associate, 1902), Pres., L. A. Williamson Co., 79 Milk St., Boston, Mass.

WILSON, Clarence C. (Junior, 1900), 22 First St., San Francisco, Cal.

WOOD, Erwin E. (1900), Life Member; Genl. Mgr., Grant & Wood Mfg. Co., Chelsea, Mich.

WRIGHT, Reginald A. (1907), Ch. Draftsman, Phila. &. Reading Coal & Iron Co., and *for mail*, 1959 W. Market St., Pottsville, Pa.

NEW MEMBERS

BAILEY, Alex. D. (Junior, 1910), Asst. to Ch. Engr., Commonwealth Edison Co., and *for mail*, 1865 S. Avers Ave., Chicago, Ill.

BANCROFT, George Arthur (Junior, 1910), Asst. to Mech. Engr., Oil Tractor Dept., M. Rumely Co., and *for mail*, 708 Harrison St., La Porte, Ind.

BARNES, Arthur F. (Junior, 1910), 119 Webster St., Worcester, Mass.

BEDELL, E. H. (Junior, 1910), 479 Ridge St., Newark, N. J.

BROWN, Walter Ellsworth (Junior, 1910), Hotel Stirling, Easton, Pa.

BURGESS, A. Bradley (Junior, 1910), Estimating Engr., Standard Plunger Elevator Co., 115 Broadway, New York, N. Y., and *for mail*, 48 N. 18th St., East Orange, N. J.

CLARK, William Van Alan (Junior, 1910), Draftsman and Inspr., Constr. Wk., Matawan, N. J.

COOLEY, Hugh Nelson (Associate, 1910), Rep., Nordberg Mfg. Co., in Southwestern U. S. and Mexico, and *for mail*, 3414 Cedar St., Milwaukee, Wis.

CORREA, William Howard (Junior, 1910), Asst. M. M., Standard Oil Co., Pratt Wks., Brooklyn, and *for mail*, 422 W. 20th St., New York, N. Y.

DAVIS, William J., Jr. (1910), Pacific Coast Engr., Genl. Elec. Co., Union Trust Bldg., San Francisco, Cal., also Ch. Engr., Mexican Northern Power Co., Montreal, Can.

DORWARD, David, Jr. (1910), Ch. Engr., Union Oil Co. of California, 235 Mills Bldg., San Francisco, Cal.

FENN, Robert Wilson (1910), Mgr. Mfg. Dept., Union Oil Co. of Cal., Mills Bldg., San Francisco, Cal.

FOLEY, Walter Joseph (Junior, 1910), Estimator, Risdon Iron Wks., and *for mail*, 115 Frederick St., San Francisco, Cal.

GERNANDT, Waldo George (Junior, 1910), Ch. Draftsman, Rapid Motor Vehicle Co., and *for mail*, Box 497, Pontiac, Mich.

GRANT, Charles C. (Junior, 1910), Goodyear Tire & Rubber Co., and *for mail* 1012 Sydney St., Akron, O.

HAMMOND, John Hays (1910), Cons. Engr., 71 Broadway, New York, N. Y.

HEIDELBERG, Frederick Martin (Junior, 1910), Asst. Labor Foreman, Am. Constr. Co., and *for mail*, 1417 Pease Ave., Houston, Tex.

HOOD, Warren Blake (Junior, 1910), Piece-Work Inspr., Canadian Pacific Ry., and *for mail*, 725 Dorchester St. W., Montreal, P. Q., Canada.

McKIBBEN, H. B. (Junior, 1910), Constr. Engr., Olathe, Colo.

MERRELL, Irving Seaward (1910), V. P. and Mech. Engr., Merrell-Soule Co., and *for mail*, 524 W. Onondaga St., Syracuse, N. Y.

MORRIS, Thomas Bray (Junior, 1910), Kilbourne & Jacobs Mfg. Co., Columbus, and *for mail*, 2846 Harrison Ave., Cincinnati, O.

OATLEY, Henry Biglow (1910), Asst. Engr., Genl. Drawing Room, Am. Loco. Co., Schenectady, N. Y.

NEIDHARDT, J. Wm. (1910), Asst. to Genl. Mgr., Detrick & Harvey Mch. Co., and *for mail*, 1807 W. Baltimore St., Baltimore, Md.

PAULSMEIER, Albert Carl (1910), Ch. Engr. and Supt., Byron Jackson Iron Wks., San Francisco, and *for mail*, 1530 Union St., Alameda, Cal.

PEPER, John Henry, Jr. (Junior, 1910), Asst. to D. S. Bushnell, Rm. 1107, 26 Broadway, New York, N. Y.

ROWLEY, Ridgway Lloyd (Junior, 1910), Inspc. Engr., Bd. of Fire Underwriters of the Pacific, 1414 Merchants Exch., San Francisco, Cal.

SCHOENIJAHN, Robert P. (Junior, 1910), Mech. Engr., L. B. Marks & J. E. Woodwell, Cons. Engr., and *for mail*, 1124 Eastern Parkway, Brooklyn, N. Y.

SNOW, Norman Leslie (Junior, 1910), Asst. Sales Mgr., Terry Steam Turbine Co., 90 West St., New York, N. Y., and *for mail*, 1342 Watchung Ave., Plainfield, N. J.

SPRAU, William C. (Junior, 1910), Mech. Engr., Arnold Co., and *for mail*, 1445 Melville Pl., Chicago, Ill.

TAYLOR, Harvey Birchard (Junior, 1910), Asst. Hydr. Engr., I. P. Morris Co., Beach and Ball Sts., Philadelphia, Pa.

THOMA, Charles, Jr. (Junior, 1910), Supt., Die Dept., E. W. Bliss Co., Brooklyn, N. Y., and *for mail*, 15 Eighth St., Carlstadt, N. J.

THOMA, Walter (Junior, 1910), Ch. Mech. Inspr., E. W. Bliss Co., Brooklyn, N. Y., and *for mail*, 15 Eighth St., Carlstadt, N. J.

YEOMANS, Lucien I. (1910), 416 E. 48th Pl., Chicago, Ill.

PROMOTIONS

BATTON, Percy H. (1901; 1910), Genl. Supt., Featherstone Fdy. & Mch. Co., and *for mail*, 21 E. Walton Pl., Chicago, Ill.

YOUNG, John Mason (1902; 1910), Dean of Engrg., College of Hawaii, Honolulu, Hawaii.

DEATHS

BETTENDORF, William P., June 3, 1910.

CRANE, William Edward, May 22, 1910.

SNOW, William W., April 26, 1910.

GAS POWER SECTION

CHANGES OF ADDRESS

FOX, John Herbert (1908), Mem. Am.Soc.M.E.
HILLEBRAND, Herman (Affiliate, 1909), 638 W. Broadway, Bethlehem, Pa.

NEW MEMBERS

BUNNELL, Sterling Haight (1910), Mem.Am.Soc.M.E.
FORSTALL, Alfred E. (1910), Mem.Am.Soc.M.E.

STUDENT BRANCHES

CHANGES OF ADDRESS

ABBISS, Reuben D. (Student, 1910), 111 Mills Ave., Braddock, Pa.
ALTEKRUSE, I. B. (Student, 1909), 808 Mulberry Ave., Muscatine, Ia.
BONNELL, W. W. (Student, 1910), 435 Franklin St., Wilkinsburg, Pa.
BRENDLIN, Wm. F. (Student, 1909), Ft. W. 57th St., New York.
CANADAY, M. S. (Student, 1909), 752 Adams St., Gary, Ind.
CLOCK, F. A. (Student, 1909,) Clockville N. Y.
COLE R. F. (Student, 1910), 16 Pleasant St., South Portland, Me.
GLICK, G. A. (Student, 1910), 110 Youngs Ave., Joliet, Ill.
HERRMANN, George A. (Student, 1909), 411 E. 40th St., Chicago, Ill.
HOMS, J. M. (Student, 1910), care Emerson-Brantingham Co., Rockford, Ill.
JACOBS, Guy W. (Student, 1910), 11 W. King St., York, Pa.
KONSTANKEWICZ, M. J. (Student, 1910), 36 Adam St., Gary, Ind.
MALONE, C. J. (Student, 1910), 173 W. Second St., Chillicothe, O.
MARSH, Karl (Student, 1910), Suite 48, The Lincoln, Youngstown, O.
MATTHAI, A. D. (Student, 1910), Sta. E., Baltimore Co., Md.
MONESTEL, Alberto A. (Student, 1910), 514 Fifth St., Brooklyn, N. Y.
MONTGOMERY, Stafford (Student, 1910), 417 Second Ave., Rome, Ga.
MORGAN, Henry (Student, 1910), 809 N. Grand Ave., St. Louis, Mo.
PARMELY, J. C. (Student, 1909), Y.M.C.A. Bldg., Kewanee, Ill.
PEARSALL, A. C. (Student, 1910), 1720 Arlington Ave., Des Moines, Ia.
PINKHAM, C. J. (Student, 1910), R.F.D. 5, Farmington, Me.
PLANK, Wm. Jay (Student, 1909), 1014 S. Main St., Wichita, Kan.
REINICKER, Norman G. (Student, 1909), Harford and Mayfield Aves., Baltimore, Md.
REYNOLDS, H. B. (Student, 1909), Wyoming, Del.
RICHARDSON, Lawrence, Jr. (Student, 1909), 413-15th St., Altoona, Pa.
SCALES, Eugene M. (Student, 1910), Guilford, Me.
SHULTS, L. J. (Student, 1909), 1847 S. Sawyer Ave., Chicago, Ill.
SPONSEL, J. G. (Student, 1909), 1429 E. 61st Pl., Chicago, Ill.
SWIGGETT, C. A. (Student, 1909), 304 W. Madison St., Iola, Kan.
WEDDELL, George C. (Student, 1910), 11 W. King St., York, Pa.
WOOD, Stanley V. (Student, 1909), 334 S. Franklin St., Wilkes-Barre, Pa.
YODER, Jacob H. (Student, 1910), 21 Chestnut St., Sharon, Pa.

NEW MEMBERS

PENNSYLVANIA STATE COLLEGE

MOLLISON, Wm. R. (Student, 1910), Scottdale, Pa.

UNIVERSITY OF ILLINOIS

BERGERT, H. A. (Student, 1910), care Mahoning Valley Wks., Youngstown, O.

HODGSON, J. H. (Student, 1910), 1919 Third Ave., Moline, Ill.

UNIVERSITY OF NEBRASKA

STANCLIFF, A. D. (Student, 1910), Pecos, Tex.

DEATHS

HASKELL, W. M., June 25, 1910.

COMING MEETINGS

AUGUST—SEPTEMBER

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN MINING CONGRESS

September 26-October 1, annual convention, Los Angeles, Cal. Managing director, Sidney Norman.

AMERICAN SOCIETY OF CIVIL ENGINEERS

September 7, 220 W. 57th St., New York, 8.30 p.m. Paper: Remedies for Landslides and Slips on the Kanawha and Michigan Railway, R. P. Black. Secy., C. W. Hunt.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES

September 6-9, annual meeting, Hotel Frontenac, Thousand Islands, Can. Secy., N. T. Wilcox, Lowell, Mass.

THE COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION

September 21-23, annual convention, Glenwood Springs. Secy., F. D. Monis, 323 Hagerman Bldg., Colorado Springs, Col.

INTERNATIONAL ACETYLENE ASSOCIATION

August 3-5, annual meeting, Congress Hotel Annex, Chicago, Ill. Secy., A. Cressy Morrison, 157 Michigan Ave.

INTERNATIONAL CONGRESS OF HIGHER TECHNICAL EDUCATION

September 9-11, Brussels, Belgium. Commissioner, Elmer Ellsworth Brown. Bureau of Education, Department of Interior, Washington, D. C.

INTERNATIONAL HUNTING CONGRESS

September 5-7, Vienna, Austria. Secy., C. Kunsky, Wiesingerstrasse 8.

INTERNATIONAL RAILROAD BLACKSMITHS ASSOCIATION

August 17-19, annual convention, Detroit, Mich. Secy., A. L. Woodworth, Lima, O.

NATIONAL ASSOCIATION OF GERMAN-AMERICAN TECHNOLOGISTS

September 1-5, Newark, N. J. Secy., B. A. von Bergen, 842 Broad St.

NATIONAL ASSOCIATION OF MASTER SHEET METAL WORKERS

August 10-13, Lulu Temple, Broad and Spring Garden Sts., Philadelphia, Pa. Secy., Otto Goebel, 523 Columbus Ave., Syracuse, N. Y.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

September Convention, Rochester, N. Y.

NATIONAL CONSERVATION CONGRESS

September 6-9, St. Paul, Minn. Secy., Thomas R. Shipp, Colorado Bldg., Washington, D. C.

NEW ENGLAND WATERWORKS ASSOCIATION
September 21-23, annual convention, Rochester, N. Y. Secy., Willard Kent Narragansett Pier, R. I.

PACIFIC COAST GAS ASSOCIATION
September 20-22, annual meeting, Los Angeles, Cal. Secy., John A. Britton, 925 Franklin St., San Francisco.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION
September 13-16, Chicago. Secy., W. E. Emery, West Chicago.

THE ROYAL ARCHITECTURAL INSTITUTE OF CANADA
August 24-27, annual meeting, Winnipeg, Man. Hon. Secy., Alcide Chausse, 5 Beaver Hall Square, Montreal.

TRAVELING ENGINEERS ASSOCIATION
August 16-19, annual convention, Clifton Hotel, Niagara Falls, Canada. Secy., W. O. Thompson, care of N. Y. C. Car Shops, East Buffalo, N. Y.

UNION OF CANADIAN MUNICIPALITIES
August 31-September 2, annual convention, Toronto, Ont. Secy., W. D. Lighthall, K. C., Westmount, Que.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
June			p.m.
1	Blue Room Engineering Society	W. D. Sprague	8.00
2	Western Union Electrical Society	H. C. Northen	7.00
7	Wireless Institute	S. L. Williams	7.30
8	Illuminating Engineering Society	P. S. Millar	8.00
9	Western Union Electrical Society	H. C. Northen	7.00
16	New York Railroad Club	H. D. Vought	8.15
16	Western Union Electrical Society	H. C. Northen	7.00
23	Western Union Electrical Society	H. C. Northen	7.00
28	Municipal Engineers of New York	C. D. Pollock	8.15
28	Western Union Electrical Society	H. C. Northen	7.00

OFFICERS AND COUNCIL

PRESIDENT

GEORGE WESTINGHOUSE.....Pittsburg, Pa.

VICE-PRESIDENTS

GEO. M. BOND.....Hartford, Conn.
R. C. CARPENTER.....Ithaca, N. Y.
F. M. WHYTE.....New York

Terms expire at Annual Meeting of 1910

CHARLES WHITING BAKER.....New York
W. F. M. GOSS.....Urbana, Ill
E. D. MEIER.....New York

Terms expire at Annual Meeting of 1911

PAST-PRESIDENTS

Members of the Council for 1910

JOHN R. FREEMAN.....Providence, R. I.
FREDERICK W. TAYLOR.....Philadelphia, Pa.
F. R. HUTTON.....New York
M. L. HOLMAN.....St. Louis, Mo.
JESSE M. SMITH.....New York

MANAGERS

WM. L. ABBOTT.....Chicago, Ill.
ALEX. C. HUMPHREYS.....New York
HENRY G. STOTT.....New York

Terms expire at Annual Meeting of 1910

H. L. GANTT.....New York
I. E. MOULTROP.....Boston, Mass.
W. J. SANDO.....Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

J. SELLERS BANCROFT.....Philadelphia, Pa
JAMES HARTNESS.....Springfield, Vt
H. G. REIST.....Schenectady, N. Y

Terms expire at Annual Meeting of 1912

TREASURER

WILLIAM H. WILEY.....New York

CHAIRMAN OF THE FINANCE COMMITTEE

ARTHUR M. WAITT.....New York

HONORARY SECRETARY

F. R. HUTTON.....New York

SECRETARY

CALVIN W. RICE.....29 West 39th Street, New York

EXECUTIVE COMMITTEE OF THE COUNCIL

ALEX. C. HUMPHREYS, *Chairman*
CHAS. WHITING BAKER, *Vice-Chairman*
F. M. WHYTE
F. R. HUTTON
H. L. GANTT

STANDING COMMITTEES

FINANCE

ARTHUR M. WAITT (5), *Chairman*
EDWARD F. SCHNUCK (1)
ROBERT M. DIXON (3), *Vice-Chairman*
GEO. J. ROBERTS (2)
WALDO H. MARSHALL (4)

HOUSE

WILLIAM CARTER DICKERMAN (1), *Chairman*
BERNARD V. SWENSON (2)
FRANCIS BLOSSOM (3)
EDWARD VAN WINKLE (4)
H. R. COBLEIGH (5)

LIBRARY

JOHN W. LIEB, JR. (3), *Chairman*
AMBROSE SWASEY (1)
LEONARD WALDO (2)
CHAS. L. CLARKE (4)
ALFRED NOBLE (5)

MEETINGS

WILLIS E. HALL (5), *Chairman*
WM. H. BRYAN (1)
L. R. POMEROY (2)
CHAS. E. LUCKE (3)
H. DE B. PARSONS (4)

MEMBERSHIP

CHARLES R. RICHARDS (1), *Chairman*
FRANCIS H. STILLMAN (2)
GEORGE J. FORAN (3)
HOSEA WEBSTER (4)
THEO. STEBBINS (5)

PUBLICATION

D. S. JACOBUS (1), *Chairman*
H. F. J. PORTER (2)
FRED R. LOW (3)
GEO. I. ROCKWOOD (4)
GEO. M. BASFORD (5)

RESEARCH

W. F. M. GOSS (4), *Chairman*
R. C. CARPENTER (1)
R. H. RICE (2)
RALPH D. MERSHON (3)
JAS. CHRISTIE (5)

NOTE—Numbers in parentheses indicate number of years the member has yet to serve

SPECIAL COMMITTEES

1910

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus — G. T. Voorhees
A. P. Trautwein — Philip De C. Ball
E. F. Miller

On Society History

John E. Sweet — H H. Suplee
Chas. Wallace Hunt

On Constitution and By-Laws

Chas. Wallace Hunt, *Chairman* — F. R. Hutton
G. M. Basford — D. S. Jacobus
Jesse M. Smith

On Conservation of Natural Resources

Geo. F. Swain, *Chairman* — L. D. Burlingame
Charles Whiting Baker — M. L. Holman
Calvin W. Rice

On International Standards for Pipe Threads

E. M. Herr, *Chairman* — Geo. M. Bond
William J. Baldwin — Stanley G. Flagg, Jr.

On Standards for Involute Gears

Wilfred Lewis, *Chairman* — E. R. Fellows
Hugo Bilgram — C. R. Gabriel
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Nominating Committee

Robert M. Hunt, *Chairman* — F. F. Gaines
Geo. M. Basford — E. M. Herr
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On Power Tests

D. S. Jacobus, *Chairman* — L. P. Breckenridge — Edward F. Miller
Edward T. Adams — William Kent — Arthur West
George H. Barrus — Charles E. Lucke — Albert C. Wood

On Student Branches

F. R. Hutton, Honorary Secretary

On Arrangements for Joint Meeting in England

Ambrose Swasey, *Chairman* — Chas. Whiting Baker, *Vice-Chairman*
Geo. M. Brill — John R. Freeman
W. F. M. Goss

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William H. Wiley, Treasurer — Calvin W. Rice, Secretary
Willis E. Hall, Chairman Meetings Committee

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1910

On John Fritz Medal

AMBROSE SWASEY (1)
F. R. HUTTON (2)
CHAS. WALLACE HUNT (3)
HENRY R. TOWNE (4)

On Board of Trustees United Engineering Societies Building

F. R. HUTTON (1)
FRED J. MILLER (2)
JESSE M. SMITH (3)

On Library Conference Committee

J. W. LIEB, JR., CHAIRMAN OF THE LIBRARY COMMITTEE, AM.SOC.M.E.

On National Fire Protection Association

JOHN R. FREEMAN
IRA H. WOOLSON

On Joint Committee on Engineering Education

ALEX. C. HUMPHREYS
F. W. TAYLOR

On Advisory Board National Conservation Commission

GEO. F. SWAIN
JOHN R. FREEMAN
CHAS. T. MAIN

On Council of American Association for the Advancement of Science

ALEX. C. HUMPHREYS
FRED J. MILLER

NOTE—Numbers in parentheses indicate number of years the member has yet to serv

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1910

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J. R. BIBBINS

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F. H. STILLMAN (1), *Chairman*
G. I. ROCKWOOD (2)
F. R. HUTTON (3)
H. H. SUPLEE (4)
F. R. LOW (5)

GAS POWER MEMBERSHIP COMMITTEE

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H. V. O. COES
A. E. JOHNSON
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A. F. STILLMAN
G. M. S. TAIT
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GAS POWER STANDARDIZATION COMMITTEE

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H. F. SMITH
LOUIS C. DOELLING

NOTE—Numbers in parentheses indicate number of years the member has yet to serve

MEETINGS OF THE SOCIETY

THE MEETINGS COMMITTEE

WILLIS E. HALL (5), *Chairman* — L. R. POMEROY (2)
WM. H. BRYAN (1) — CHAS. E. LUCKE (3)
H. deB. PARSONS (4)

Meetings of the Society in Boston

IRA N. HOLLIS, *Chairman* — I. E. MOULTROP, *Secretary*
EDWARD F. MILLER — J. H. LIBBEY

Meetings of the Society in St. Louis

WM. H. BRYAN, *Chairman* — ERNEST L. OHLE, *Secretary*
R. H. TAIT, *Vice-Chairman* — FRED E. BAUSCH
M. L. HOLMAN

OFFICERS OF STUDENT BRANCHES

INSTITUTION	BRANCH AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	PRESIDENT	CORRESPONDING SECRETARY
	1908			
Stevens Inst. of Tech., Hoboken, N. J.	December 4	Alex. C. Humphreys	H. H. Haynes	R. H. Upson
Cornell University, Ithaca, N. Y.	December 4	R. C. Carpenter	C. C. Allen	C.F. Hirschfeld
	1909			
Armour Inst. of Tech., Chicago, Ill.	March 9	G. F. Gebhardt	F. E. Wernick	W. E. Thomas
Leland Stanford Jr. University, Palo Alto, Cal.	March 9	W. F. Durand	A. F. Meston	J. B. Bubb
Polytechnic Institute, Brooklyn, N. Y.	March 9	W. D. Ennis	J. S. Kerins	Percy Gianella
State Agri. College, Corvallis, Ore.	March 9	Thos. M. Gardner	C. L. Knopf	S. H. Graf
Purdue University, Lafayette, Ind.	March 9	L. V. Ludy	H. A. Houston	J. M. Barr
University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	C. E. Johnson	C. A. Swiggett
New York Univ., New York	November 9	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois, Urbana, Ill.	November 9	W. F. M. Goss	B. L. Keown	C. S. Huntington
Penna. State College, State College, Pa.	November 9	J. P. Jackson	G. B. Wharen	G. W. Jacobs
Columbia University, New York.	November 9	Chas. E. Lucke	F. R. Davis	H. B. Jenkins
Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	Morrill Mackenzie	Foster Russell
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	C. C. Thomas	John S. Langwill	Karl L. Kraatz
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	R. V. Aycock	Osmer Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wohlenberg	W. H. Burleigh
	1910			
Univ. of Maine, Orono, Me.	February 8	Arthur C. Jewett	H. N. Danforth	A. H. Blaisdell
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	C. B. Boles	W. Q. Williams